COTTON RESEARCH IN MYANMAR: AN OVERVIEW

Tun Win

（*Research officer for cotton farms，Cotton and Sericulture Department*）

1 Background

Cotton, with an average annual sown area of 314 thousand hectares recorded for ten years ending 2007, takes priority over all other fiber crops in Myanmar. On the evidence of some historical records, it is likely to be thought that cotton cultivation and utilization have been started since in the early days of Myanmar history.

Cotton research was initiated in central farm, Mandalay, Myanmar, along with the establishment of the Department of Agriculture by the then government in 1906. Based on the research findings, systematic line sowing in cotton cultivation was introduced in 1927. Until then broadcasting sowing method had been traditionally practised (chit, 2005). The department carried out hybridization and selection research programme for the development of indigenous cotton varieties, *Gossypium arboreum*, around 1920 s.

Agricultural and Rural Development Corporation (ARDC) the government agency_ was established in parallel with the Department of Agriculture under the same ministry in 1953-1954. The corporation introduced upland cotton, *G. hirsutum* from U.S.A and former U.S.S.R in 1957. After conducting adaptive field trials, the corporation distributed some *hirsutum* varieties commercially in 1960. Furthermore, the corporation set up two central farms_ Hlaingdet farm in 1957 and Lungyaw farm in 1963 _ to conduct field research and seed multiplication of *hirsutum* cotton. ARDC carried out research on varietal development and agronomic management for *hirsutum* cotton in those farms. Due to the introduction of upland cotton, *G.hirsutum*, provision of basic farm inputs and appropriate technology package by the corporation, swift progress in seed cotton production was gained in both quality and quantity.

In 1972, the then Ministry of Agriculture and Forestry combined two parallel agencies _ Department of agriculture (DA) and Agricultural and Rural Development Corporation (ARDC)_ into one agency named Agriculture Corporation (AC). It took responsibility for managing agricultural crops production, extension, input supply, procurement, ginning and research. Agriculture Corporation implemented the Cotton and other Industrial Crops Development Programme assisted by UNDP/FAO during mind 1970 s and 1980 s. That project developed a multi -disciplinary research programme for cotton improvement involving varietal introduction, selection and breeding, agronomic management. Research on plant protection techniques targeted on the control of jassids and bollworm complex was also developed during this project. Moreover, the programme contributed to the establishment of a cotton fiber and miniature spinning laboratory which is essential to support the cotton varietal improvement programme, in early 1980 s. Thus, MCSE (2006) mentioned that "the development of cotton in Myanmar could be largely attributable to the UNDP/FAO assisted Cotton and other Industrial Crops Development Programmes". Despite this, it was impossible that cotton was always the centre of attention because Agriculture Corporation undertook responsibilities for not only cotton sector alone but also all other commercial crops.

Therefore, Myanma Cotton and Sericulture Enterprise (MCSE) was established at the beginning of the 1994-1995 financial year, under the restructured Ministry of Agriculture and Irrigation (MOAI) to strengthen the cotton sector. All the responsibilities of cotton cultivation, research, supply of chemicals, procurement of seed cotton, ginning, supply of cotton lint and by products to state owned cotton industries and the export were taken by MCSE. In 2005, the functions of MCSE had been reassigned to focus on research and development, extension and training functions rather than commercial activities (MCSE,

2006). There followed a slight change from Myanma Cotton and Sericulture Enterprise (MCSE) to Cotton and Sericulture Department (CSD). At present, CSD is most responsible for cotton research.

2 Structure and Organization of Cotton Research

Organizational structure of cotton research is presented in Figure 1. The most responsible person for cotton research in head office level, is Dy. Managing Director followed by General Manager for extension and planning division. For regional level, office of Dy. General manager for seed development and research is set up in Meikhtila township, a place in the proximity of all research sites. Dy.General Manager for seed development and research supervises all activities taken place in cotton research and seed farms. In additions, the Dy. General Manager directly manages the functions of cotton fiber and miniature spinning laboratory. To closely supervise the research activities and research teams in research and seed farms, a research officer for cotton farms is assigned.

In principle, an official meeting between head office level officers and farm managers is held at least once a year. All researchers have to attend one section of that meeting which is mainly associated with the formulation and review of research activities. In some years, a meeting for the formulation and review of research activities is separately convened by Dy. Managing Director at major research site, lungyaw cotton research and seed farm. Some important findings and research papers are annually presented in national level seminar organized by Myanmar Academy of Agricultural, Forestry, livestock and Fishery Sciences. There are two other institutions_ Yezin Agricultural University and Department of Agricultural Research. These institutions also carry out research on cotton to some extent in collaboration with Cotton and Sericulture Department, despite the fact that CSD is the principal department for cotton research.

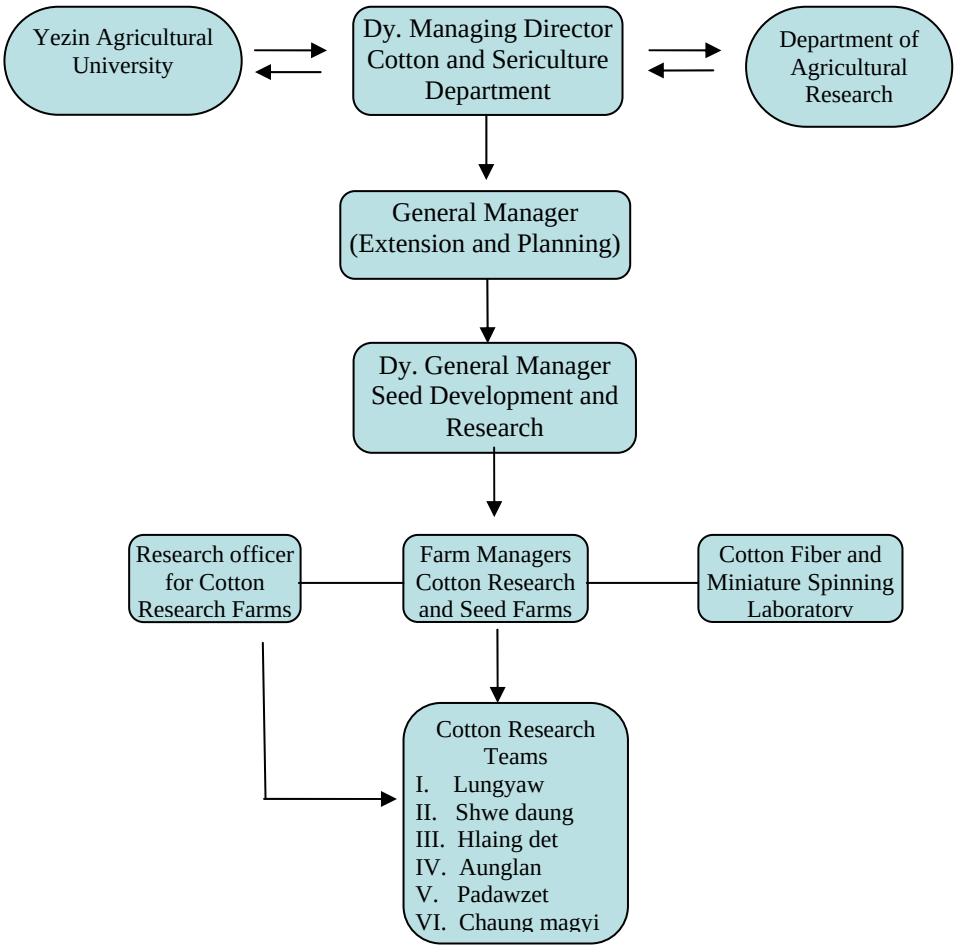


Fig.1 Structure and Organization of Cotton Research

3 Cotton Research Sites

Myanmar's cotton producing region covers most of the central part of the country between the 600 mm and 1000 mm rainfall isohyets. Consistent with the CSD's directive to regionalize research programmes, field experiments and trials are mainly conducted in department owned cotton research and seed farms which scatter within major cotton producing zones. (see Fig.2). According to their workload, research sites are arranged in descending orders as follows:

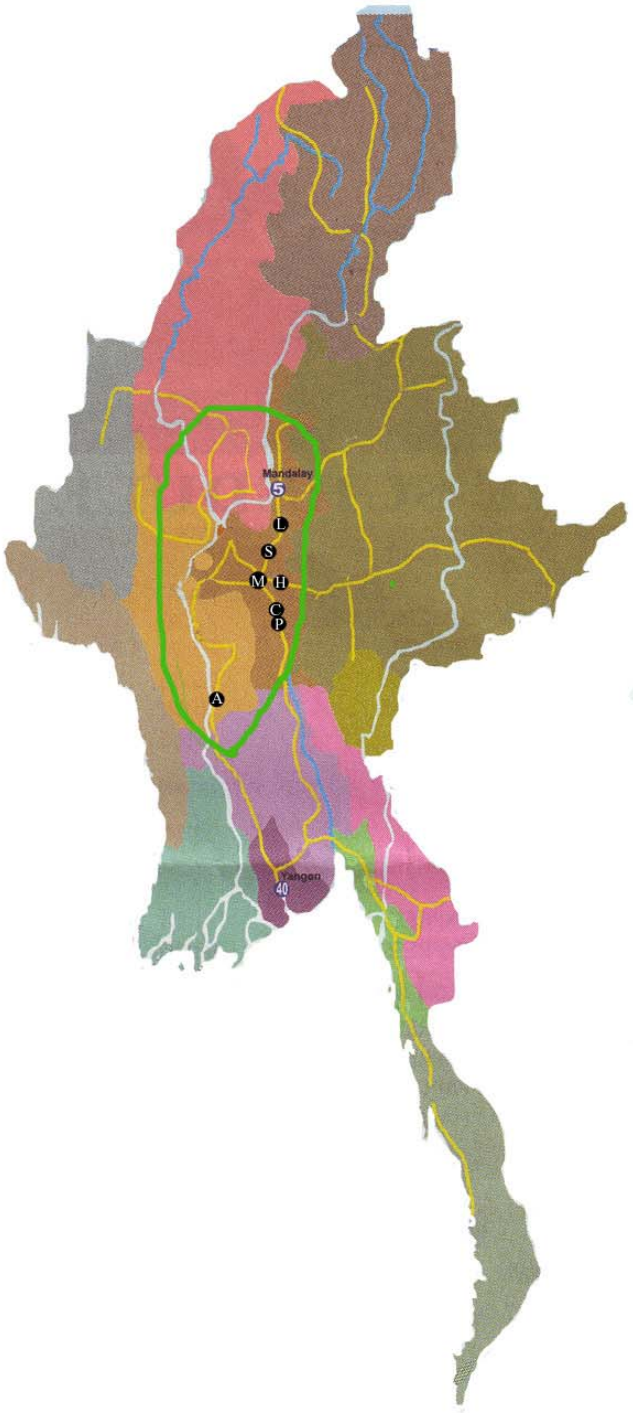
Farm 1. Lungyaw cotton research and seed farm
Farm 2. Shwedaung
Farm 3. Hlaing det
Farm 4. Aunglan
Farm 5. Padawzet
Farm 6. Chaungmagyi
Farm 7. Pyaw bwe

Farms are responsible for not only research but also multiplication of quality seeds of improved varieties. Some of the available facts and figures about the research sites are shown in table 1.

There is only one research site other than the farms, a cotton fiber and miniature spinning laboratory which is a sine qua non for any cotton improvement programme. It has been set up in Meikhtila township since early 1980 s.

4 Review of Recent and Current Research Formulation and Activities

The annual meeting of the formulation and review of research activities generally plays a key functional role in the current research operations. It aims: to support improved agricultural technology in order to respond to producer and business needs; to adapt research programmes to different agro ecological conditions and to the consequences of pressing problems and issue in cotton production; and to help the cotton growers to keep competitive with other crops growers in the agriculture market.



L= Lungyaw farm; S= Shwedaung farm; A= Aunglan farm; H= Hlaing det farm; C= Chaung Magyi farm; M= Padawzet farm; M= Fibre quality lab; P= Pyaw bwe farm.

Fig . 2 Cotton Research Sites.

Table 1 Facts on Cotton Research sites (research and seed farms)

Sr No.	Farm	Location			Normal Climatic Condition				Year of Establishment	Total Land Area (ha)
		North Latitude	East Longitude	Altitude(meter)	Max Temp c˚	Mini Temp c˚	Rainfall (mm)	No. of raining days		
1	Laungyaw	21˚	96˚	367	37.73	21.46	677	56.9	1963	3033
2	Shwedaung	21˚ 16'	96˚	373	39.44	20.00	550	40.0	1982	437
3	Hlaingdet	20˚ 40'	96˚ 11'	-	37.1	17.97	850	53.0	1957	607
4	Aunglan	19˚ 10'	95˚ 22'	108	37.1	17.95	968	70.0	1921	57
5	Padawzet				36.0	20.5	896	57.0	1984	8.2
6	Chaungunagyi				37.8	20.3	847	70.0	1982	24.4
7	Pyawbwe				38.77	20.1	1163	63.0	1984	8.8

Research activities can be categorized as follows: varietal improvement and identification of varieties suitable for multiple cropping system; improving agro-technology and management practices to maximize returns under smallholder farming conditions; seeking improved plant protection measures; and economics of cotton production.

4.1 Varietal improvement programme

Varietal improvement programme comprises three types of issue:

- breeding, hybridization and selection;
- germplasm collection and maintenance, and
- variety maintenance and seed multiplication.

4.1.1 *Breeding hybridization and selection.* Breading research put emphasis on the attainment of locally developed new and better varieties to reduce the heavy reliance on introduced cotton varieties in cotton production. The fibre quality of present commercially grown cotton cultivars can basically meet the needs of textile industry but it still need to be improved especially in ginning percentage. At present, four promising cotton cultivars which posses greater ginning percentage, have been locally developed through conventional breeding. Since more precise varietal regionalization would significantly improve production, those newly developed varieties are under regional varietal trials. Afterwards, varietal replacement will be carried out if necessary. Fiber qualities of newly developed varieties and present commercial cotton varieties are shown in following table 2.

Table 2 Mean value of the fiber qualities of commercially grown and newly developed cotton cultivars

Varieties	Ginning percentage	Fiber Length (mm)	Fiber strength (lb/mg)	Fiber Finess (micronaire)
Commercially grown cotton cultivars				
Ngwe chi 1	35	27.0	8.0	4.2
Ngwe chi 2	36	28.9	8.3	4.0
Ngwe chi 3	34	30.2	8.7	3.4
Ngwe chi 4	34	29.4	8.4	3.5
Ngwe chi 5	35	27.7	8.3	4.1

Locally developed new varieties				
SDG - 1	40	28.0	8.5	4.2
SDG - 4	45	26.0	8.0	5.0
SDG - 6	41	29.0	8.3	5.4
SDG - 8	41	29.0	7.9	5.1

Source:1. Cotton in Myanmar (MCSE, 2006); 2. Annual research report, Shwedaung farm (2007).

High yielding, good fiber quality, earliness, draught resistance, disease and pest tolerance are traits to be considered in varietal selections. Among them, pest tolerance is more desirable trait for Myanmar cotton farmers. Thus, five promising new varieties have been developed by backcrossing. In comparison with present commercial varieties, those are relatively tolerable to sucking pests, jassid and aphids, and bollworm complex. Such five promising varieties are also under field trials for regionalization.

4.1.2 *Germplasm collection and maintenance.* As germplasm resources are important bases for cotton breeding, one of the major activities practised by cotton and sericulture Department, is germplasm collection and maintenance to enrich the gene pool. The task consists of collection of different exotic and indigenous cotton cultivars, maintenance of their genetic purity by self-fertilization and by growing the seeds every year at two sites and maintenance of the records of the cultivars' vegetative, generative and fiber quality traits.

Cotton germplasm resources in Myanmar is comparatively very small. Altogether 493 accessions are simultaneously preserved in Cotton and Sericulture Department and gene bank of Department of Agricultural Research. These accessions are composed of:

Gossypium hirsutum - 372,
G. barbadense - 8, and
G. arboreum - 113.

4.1.3 *Variety maintenance and seed multiplication..* It is also one of the components of varietal improvement programmes. Nucleus seeds of the commercially grown varieties are produced in research fields. The nucleus seeds are systemically multiplicated in seed farms and registered seeds are sold out yearly to contact farmers for variety maintenance.

Furthermore, conventional hybrid cotton seed production is currently in progress at the two research and seed farms, lungyaw and Shwedaung.

4.2 Improving agro-technology and management practices

Appropriate agro-technique and crop management practices for realising better yield with least cost is currently in demand because of progressive reduction of agricultural subsidy and rising of input cost. In accordance with the pressing problems, agro-technique research programmes have been formulated to develop methods of using farm waste for soil fertility improvement and home-made micronutrient foliar fertilizer.

Preparation methods for compost and methods of application have been disseminated according to the following finding.

Table 3 Effect of inorganic fertilizers, manures and bio-fertilizers on seed cotton yield (mean value of second season test)

Treatments	Plot Yield (kg)	Estimated Yield (kg/ha)
1. Biocomposer (commercial grade I, 500 kg/ha)	10.3	2462

2. Biocomposer (commercial grade II, 600 kg/ha)	10.5	2509
3. Linter waste compost (1000 kg/ha)	12.2	2673
4. Cotton Seed cake compost (1000 kg/ha)	12.3	2940
5. Leaves and plant debris compost (25 metric tons/ha)	10.4	2485
6. Cow dung manure (25 metric tons/ha)	11.7	2794
7. Inorganic check (N; 28.5 kg: P, 27.8 kg: K, 37 kg)/ha	9.9	2362
8. Check.	6.0	1434
F. test	**	
CV %	13.31	
LSD (0.05)	3.33	

Source: Annual research report; Shwedaung farm (2007).

Three times split application of home-made boron foliar fertilizer at the cotton square initiation, flower initiation and full blooming stages was found to significantly increase the yield in sandy and sandy loam soil. Utilization of this fertilizer is, now, widely practised in those area.

Table 4 The effect of home-made boron foliar fertilizer on seed cotton yield (mean value of two seasons)

Treatments	Harvested boll per plant	plot yield (kg)	Estimated Yield (kg/ha)
1. one spray at first squaring	13.3	9.59	2294
2. one spray at first flowering	16.3	10.03	2399
3. one spray at full blooming	15.3	9.77	2336
4. two sprays at first squaring and first flowering	17.1	11.04	2640
5. two sprays at first flowering and full blooming	18.3	11.22	2683
6. three sprays at first squaring, flowering and full blooming	20.0	12.04	2880
7. check	13.0	7.20	1722
F. test	**	*	
CV %	10.7	12	
LSD (0.05)	4.4	2.2	

Growing cotton as a sole cropping became uneconomical around 2005, since financial return per unit of capital invested in cotton production sharply dropped to 0.23 in average. Cotton based intercropping methods which are competitive with other crops production, were, then, determined, in accordance with the prevailing crop prices. The most profitable intercropping methods of cotton-green gram, cotton-sesame and cotton-chilli, have been informed to cotton farmers through extension agents.

Varietal replacement has been carried out in large-scale during 2003 to 2005. In accordance with new introduced varieties, adaptive research programmes concerning with planting density, irrigation, fertilizer, time of sowing and crop physiology were conducted and generated technical package for crop production.

Experiments on growth analysis and plant mapping was carried out on the currently grown commercial cotton cultivars to study cotton plant physiology. The result provided researchers as well as procedures or farmers with helpful indicators for cotton crop management and maximizing potential yield. Moreover, the research also supported information about the effect of fruiting sites on yield of commercial cotton cultivars.

Table 5 Average seed cotton yield (kg/ha) over cotton cultivars, *G.hirsutum*, for each fruiting position by combination of sympodial branches (up to position three)

Sympodial branch	Fruiting position		
	one	two	three
1-3	351.08	249.94	105.29
4-6	336.80	238.47	81.16
7-9	243.29	137.26	56.75
10-12	106.33	64.75	59.15
13-15	60.59	35.43	45.99
>15	34.17	13.20	21.55

LSD (0.05) = 32.34； F * (Significant at 0.05 level).

Domestic cotton market was virtually liberalized in recent years. Uprising trend of seed cotton price is, now, being observed. Farmers might allocate more inputs in cotton production if it is economical. Cotton grown under high fertility situations will require growth regulators or growth management practices to attain adequate vegetative growth control. Agro-technique research on updated growth regulating technique is in progress now. Furthermore, optimum planting density in various ranges of fertilizer application might need to recommend more precisely. Thus, field trials on this issue are under examination in two different sites.

4.3 Seeking improved plant protection measures

Yield losses ranging from 30 to 70% in cotton production in Myanmar, is attributed to the damage inflicted by bollworms such as *Heliothis armigera* and *Pectinophora gossypiella*. So, seeking improved plant protection measures in harmony with IPM system is always the priority in cotton research even though the implementation of IPM in farm level is still poor. One of the efficient ways to resist bollworms attack is supposed to be the adoption of genetically engineered (GE) cotton, i.e., Bt-cotton cultivation. Although the issue needs further examination, field trial relating to feasibility of Bt-cotton cultivation was conducted in lungyaw cotton research and seed farm where the bollworm pressure is higher than other research sites. Field resistance to bollworms and potential for saving insecticides with the use of Bt-cotton revealed encouraging results.

Table 6 Potential for saving insecticides with the use of Bt.cotton and the profitability of treatments

Treatments	Frequency of chemical spray per season		Total cost that vary (k/ha)	Net Benefit (k/ha)
	for sucking pest	for bollworm		
1	-	-		301,956
2	-	-	25,822	400,771
3	-	-	34,594	284,066 D
5	3	-	38,152	369,167 D
4	-	8	48,827	358,492 D
6	2	-	55,745	409,359
7	3	-	72,746	332,003 D

K = unit of local currency; D = Dominated treatment. Treatments：1. Control；2. Seed dressing (5gm of Imidacloprid 70% WP/kg of seed)；3. 12.5 kg of Furadan 3G/ hectare put together with seed at sowing；4. Farmer practice; spray for bollworm with 10 days interval from first squaring to 100 days after emergence.5. Spray based on ETL (for jassid, aphids and bollworm complex) from first squaring to 100 DAE；6. Treatment 2 plus 5；7. Treatment 3 plus 5.

Tested Bt-cotton cultivars were so glabrous that some amount of chemical sprays was still in need to check the sucking pest population growth.

Biological control of a serious sucking pest, aphids, would be helpful to minimize the sprays. Moreover, in conventional *hirsutum* varieties cultivation, minimum number or avoidance of chemical sprays on early season sucking pests would spare the beneficial insects which contribute to suppression of bollworms in the later stages. To avoid the sprays on the early season serious sucking pest, *Aphis gossypii*, the lady bird beetle, *Menochilus sexmaculatus* Fabricius has been reported as a good beneficial for biological control of cotton aphids. Methods of mass rearing of *M. sexmaculatus* has been developed. To maintain the sustainable biological control of cotton aphids, the predators should be kept to retain on the cotton ecosystem by providing certain number of aphids. The release of the predators is under progress in cotton research and seed farms.

Table 7 Retaining times and threshold numbers of *M.sexmaculatus* stages based on ANOVA and differential formula

Stages	ANOVA		Differential formula	
	Retaining threshold (TIES)	Maximum retaining times	Retaining threshold (TIES)	Maximum retaining time
1st instar	8.00	725.80	10.60	745.09
2nd instar	40.00	789.40	42.89	796.35
3rd instar	48.00	730.60	79.35	823.28
4th instar	125.00	877.80	197.25	955.97
5th instar	270.00	864.00	322.25	862.08

TIES = Third Instar Equivalents of *A.gossypii.*

In cooperation with the Myanmar Agriculture Service, mass rearing of another potent predator – the bugs of the genus *Eocanthecona furcellata* (Wolff) has been carried out at the biological control lab of Myanma Agriculture service. Test release of the bugs has been initiated in two research sites named lungyaw and Shwedaung farms. Assessment of the impact will be a future research programme.

Severe infestation of perennial weeds especially Bermuda grass, *Cynodon dactylon*, in some cotton growing areas was reported. It is difficult to control such weed by hoe weeding alone due to its underground rhizome. Labour scarcity is another difficulty. So, evaluation of the efficacy and economic profitability of various weed control methods which are the different combinations of hoe weeding and glyphosate [N-(phosphonomethyl) glycine, isoproplamine salt], was carried out. That provided the cotton farmers with the most efficient and profitable methods.

Table 8 Yield components, yield and benefit cost ratio at different weeding treatments

Treatments	No. of boll per plant	Boll weight (gm)	Seed cotton yield (kg/ha)	Benefit cost ratio
1. H (20 DAE) + G (40 DAE)	9.8 bc*	2.9	1229 c	1.33
2. H (20, 80 DAE) + G (40 DAE)	9.1 bc	2.9	1266 c	1.31
3. H (20, 40 DAE) + G (60 DAE)	11.0 bc	3.0	1043 bc	1.08
4. H (20,40,60,80 DAE)	11.2 c	2.9	1280 c	1.28
5. G (20 DAE) + H (60 DAE)	7.4 ab	3.0	684 b	0.74
6. G (20 DAE) + H (60,80 DAE)	7.5 ab	2.6	693 b	0.72
7. G (20,60 DAE)	8.8 bc	2.6	819 b	0.87

8. Unweeded check	4.0 a	2.4	186 a	0.23
Pr. < 0.05	0.011	0.196	0.000	
CV %	28.7	12.6	27.3	
LSD (0.05)	3.6	-	361.9	

* Any two means having a common letter are not significantly different at 5 % level; DAE = Days after crop emergence; H = hoe weeding, G = glyphosate.

4.4 Production economics

Research on production economics in cotton production has been initiated in 2003/04. The stochastic frontier production function was used to estimate the farmers' production proficiency in given input use through technical efficiency measurement in major premonsoon season cotton growing area. It was found that the mean technical efficiency of 0.67 was achieved by premonsoon cotton farmers in the survey area. Thus, in the short run, there is a scope for increasing cotton production by 33 % by adopting the technology and the techniques used by the best practice cotton farm. Low seed quality and the disproportional combination of inputs used in cotton production were found to be the major causes for yield reduction.

Probit model was, then, employed to analyze the factors affecting the adoption of improved technologies. Among sample farmers, 42% were categorized as adopters and 58% as non-adopters. But, all sample farmers were not fully utilized the recommended technologies. According to the survey, land fragmentation, use of hired labor, annual income, education level and attendance on farmers' meeting programme were found to be significant factors affecting the adoption.

5 Future research interest

The ability to steer the source – sink relationship in cotton could be helpful to maximize yield. Rational application of inputs which harmonize with the crop physiology and biology need to be informed to farmers. Thus, strengthening academic research on cotton crop physiology will be given priority in future research programme.

Future research will also emphasize to develop techniques to increase seed setting and improve seed quality in hybrid seed production to reduce the cost of seed production.

At present, CSD is unable to access to good laboratory for academic research on biotechnology. Research programmes on biotechnology and plant nutrition are collaboratively carried out with Department of Agricultural Research and Myanmar Agriculture Service which have good labs. CSD usually arranges to include cotton research related with lab experiment, in their course of research plan. CSD has made discussion with these institutions to evolve molecular biology based technology to get genetic information using molecular markers.

Regarding with pest control, study on biology and identification of cotton stem weevil *Pempherulus affinis* is of interest. The infestation of cotton stem weevil was, previously, very sporadic and very rare. Now, the infestation become common and damage is obviously noticed in some cotton growing area

especially in research and seed farms where cotton is grown continuously. Pouring the diluted insecticide solution to the crown portion of the young plant and soil, was found to be effective to control the stem weevil but it is impracticable for large area. Thus, finding control measure for this pest is another area of future research.

Economic analysis approaches to cotton production constraints is also a component of future research interest. Cotton production constraints have been generally identified except marketing aspects. It need to investigate how these constraints are interdependent and affect cotton production. Moreover, cotton marketing aspects should include in the analysis.

As agriculture market comparatively more liberalize, cotton production become competitive with production of alternative crops. To maximize the net return to the cotton farmers, the recommendation of fertilizer application for the optimum yield will be the future need. Therefore, economic rate analysis of major element fertilization in cotton will be one of the area of future research.

6. Conclusion

As mentioned above, almost all research programmes are still conventional although cotton research has been initiated since 1906. Biotechnology related cotton research and in-depth study on crop physiology and nutrition have been implemented with the cooperation and collaboration of other departments under Ministry of Agriculture and Irrigation. Cotton and Sericulture Department has enough land and labour resources and some extent of technicians to handle various type of cotton research. At present, research programmes put emphasis on the pressing problems such as seed development, technology package concerning with cultivation practices for new varieties, screening of insecticides suitable for cotton pest control and so on. Our future research aim is to attain a better understanding of cotton response as related to input use. Furthermore, cultivation of Bt-cotton is in farmers' demand though bio-safety frame work and legal procedures are under process. So, research works related with GE cotton is also necessary. Moreover, socio-economic research to investigate the causes which hamper the progress of cotton production is also a future need. Therefore, our hope is the same to that of the Cotton Research Institute, Chinese Academy of Agricultural Science. They mentioned that "the workshop will provide an excellent opportunity for the Asia cotton sci-tech field to communicate, formulate and coordinate future collaborative activities on cotton research of common interest."

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