Compliance with regulations: Experiences from Roundup-ready cotton field trials in Uganda

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Abstract

Roundup-ready cotton was tested under confined field trials at NaSARRI-Serere in Eastern Uganda and Mubuku Prison Farm- Kasese, Western Uganda for the first time during the 2009/2010 and 2010/2011 cotton seasons. Weeds were controlled using two dosages of Roundup. These were the recommended rate and twice the recommended rate applied to transgenic cotton once or twice. The recommended rate was applied at 220 mls/15 litres of water, while the double rate was applied at 440 mls/15 litres. For the BPA 2002 control commercial variety, weed control was done through hand weeding three times. Major weeds of cotton were fully controlled by herbicide application at the two rates applied twice on the transgenic cotton without any negative effect to the cotton crop. At NaSARRI during the second season, application of the recommended rate of roundup twice to variety SG 125RRFlEX gave seed cotton yields of 1015.6 kg/ha, compared to 1265.6 kg/ha when the rate was doubled and applied twice. The local commercial variety BPA 2002 hand weeded three times during the same season yielded 1495.6 kg/ha. The results point to the prospective success of herbicide use on transgenic cotton under Ugandan conditions and strengthen the need for introgression of the technology to the local cotton varieties in the country.

This paper presents details of results from the two locations in the two seasons.

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Introduction

Three aspects describe cotton in Uganda.

(1) It was introduced in 1903 and quickly established as a major export crop and number one foreign exchange earner, until it was surpassed by coffee in the 1950's. It contributes significantly to Gross Domestic Product (GDP) of the economy of Uganda, and earned $48 million during 2010/2011 period from exports (New vision, 31st October, 2012).

(2) It is an important cash crop of strategic importance to the economy. Its position in farming systems contributes significantly towards food security. In some cases cotton is used as a land opener thus leaving a clean seedbed for the next crop in the rotation. Cotton is also intercropped with other crops like beans, cowpeas, groundnuts, green grams, soybean, and pigeon pea thus ensuring food and financial securities for the farmer.

(3) Its production is basically by small holder farmers with less than 10 acre holdings and contributes to the income of approximately 10% of the country's population while providing employment to a majority of people along the cotton value chain (Serunjogi, 1999). Main producing areas are in eastern, northern and western Uganda. Cotton production reached its peak in the late 1960's and early 1970's, with an average production of 465,000 bales of lint annually. This was contributing 40% to the country's foreign exchange earnings. Production drastically declined in the 1970's and 1980's due to political instability, hitting a record low of 11,000 bales of lint (CDO, 2009). Major contributors to declined production were: (a) unstable market prices, (b) insect pests attack to cotton at all growth stages (seedling, vegetative and maturity) causing 40 to 100% crop loss, (c) new diseases like wilts which devastate cotton in many areas (d) declining soil fertility in most of the cotton growing areas (e) farmers' inability to effectively apply production inputs and (f) competition from weeds which also harbor pests, are expensive to control and cause 30 – 100% crop loss. All these constraints can cause crop loss of up to 100,000 bales of lint, equivalent to US$ 20 million in export value. Nevertheless, Uganda still produces high quality, medium-long staple cotton which guarantees a stable demand at the international market.

Weeds are a big problem to cotton production in Uganda. Up to 98 % of cotton farmers in Uganda weed cotton by hand, 1.5 % use tractor and ox drawn weeders at one time, while 0.5 % use herbicides. Studies conducted at Serere revealed sharp increases in seed cotton yields, revenue, gross margins and costs with increased weeding frequency up to four times (Elobu et al, 1998). Beyond this frequency, the increases were low and gross margins fell.

The technology of transgenic herbicide tolerant (HT) plants has reduced the cost of weed control and boosted the production the production of several crops such as soya beans, maize, cotton, etc in several countries. For the case of cotton, Monsanto developed a technology in which a gene picked from a bacterium (*Agrobacterium tumefaciens)* and inserted in the plant genome. The gene leads the plant to produce enzymes that make it resistant to glyphosate. Glyphosate is the

active ingredient in Roundup which is responsible for killing all plants to which the herbicide is sprayed.

The objective of this work was therefore to assess the ability of Monsanto's genetically modified (GM) cotton varieties to tolerate applications of Roundup herbicide, as a weed control method under Uganda's conditions. The gene was later to be introgressed into Uganda's cotton varieties for commercial production after three years of confined field trials, if results were promising.

Materials and methods

Compliance with regulations

An application for confined field trials was made to the National Biosafety Committee (NBC) in 2007 and after thorough screening it was approved leading to issue of import permit for transgenic seed from Monsanto, USA in 2009. All activities during the trials were accomplished in conformity with the standard operating procedures (SOPs) (UNCST, 2006).as outlined in the *Confined Field Trials Guidelines for Uganda* and *Trial Manager's Handbook.* Some of the major compliance areas involved were:

(a) CFT structures.

Confined field structures were constructed at NaSARRI and Mubuku. These included a fencing around the cft site, a strong gate that was guarded 24 hours, an office for the security guards who did not have access to the trials inside, toilet facilities for the security guards outside and for the workers inside, stores inside for all the materials used in the study and an incineration pit for destruction of all materials within the site, after use, etc. All these were inspected by NBC and approved for use.

(b) Shipment

The shipment and handling of all seed for planting in the two locations was done according to guidelines. The different transgenic cotton varieties imported were separately packed in appropriate bags that prevented them from mixing with each other. These bags were then packed into a larger bag with proper resistance to moisture. The consignment was properly lebelled "GENETICALLY MODIFIED SEEDS FOR RESEARCH PURPOSE ONLY" and was accompanied by a phytosanitary certificate. These consignments were declared at the airport received by the Principal Investigator, accompanied by an Inspector up to the time of delivery to the CFT store at NaSARRI.

© *Trainings*

A number of trainings were conducted for all people involved in the trial both at NaSARRI and Mubuku, to keep them abreast with the standard operating procedures (SOPs) during conduct of the trials. Some of the trainings were conducted before the trials while others kept being done as trials were going on.

(d) Regular inspections

Inspectors from NBC and MAAIF were involved at all stages to ensure that work was going on as planned. Reports from these Inspectors and the Trial Managers helped NBC to keep track with the trials according to required regulations. Very often, the NBC team visited the trials at both sites.

Season one 2009/2010

Cotton was planted under confined field trials at the National Semi Arid Resources Research Institute (NaSARRI) in Serere district on 1st July 2009 and at Mubuku Government Prison Farm in Kasese district on 7th September 2009. All cotton at NaSARRI, including buffers were planted at a spacing of 75 cm between rows and 30 cm within rows (75x30), while at Mubuku the spacing was 90 x 30 cm. Buffer zones of 12 m were planted with BPA 2002 cotton variety, to intercept pollen from the transgenic varieties. At thinning, only one plant was left per station giving plant populations of 44,444 and 37,037 plants per hectare for NaSARRI and Mubuku respectively.

Fourteen (14) treatments were studied in this trial. They comprised of five cotton varieties, two hand weeding and three herbicide application schedules. The five varieties were SG125RRF and DP110 which were transgenic and had the gene for resistance to roundup, their isolines (SG 125 and 99M03, respectively) and the non-transgenic Ugandan commercial variety (BPA 2002). The two hand weeding treatments were 100 % weed-free throughout the season and Ugandan Farmers' practice of weeding three times. The three herbicide application schedules were 220 mls of Roundup/15 litres of water applied once over the top of cotton, 220 mls/15 litres applied twice over the top of cotton, and 440 mls/15 litres applied twice over the top of cotton.

The experiment was a RCBD with 4 replications. Plots measured 3.75 m wide x 12 m long at NaSARRI, and 4.5 wide x 12 m long at Mubuku. These plots contained six cotton rows, but all data was recorded from the two middle rows. At harvest, cotton for yield data was picked from four middle rows leaving three stands on either ends of each row.

Plant stand counts for cotton, and data on weed species and counts, were recorded before and after any herbicide application. Weed data was taken from two stations of 0.5 m^2 per plot. These stations pegged for repeated use each time weed data was taken.

Roundup was then sprayed to cotton according to the different treatments immediately after data collection and then repeated for some treatments when weeds came up. Thick polyethylene papers were held upright around the plots being sprayed during herbicide application to prevent herbicide drift to non-target plots. Sucking pests, especially aphids, white flies, lygus, etc, were controlled from all plots using Golan at a rate of 24 mls /15 litres of water while bollworms were controlled by sprays with Twiga Cyper at a rate of 120 mls /15 litres of water. At the end of each trial and after taking all the required data, all the cotton from the confined field trial sites was incinerated in the incineration pit within the facility.

Season two 2010/2011

The trials were repeated with some modifications and planted at NaSARRI and Mubuku on 23rd and 27th September 2010, respectively. This time twelve treatments were studied and they were composed of: (a) four varieties *(*SG 125RRF with single gene for tolerance to Roundup herbicide, SG 125 B2RF with stack genes for Roundup tolerance and bollworm resistance, their isoline SG 125 and the local commercial BPA 2002 as the local control. (b) Two hand weeding methods *(*100 % clean throughout season, which was achieved by weeding 6 times, and weeding as the Ugandan farmers do, which was done thrice. (c) Three herbicide application schedules (the recommended rate of 220 mls/15 litres applied once over the top of cotton, the recommended rate of 220 mls/15 litres applied twice over the top of cotton, and double the recommended rate that is 440 mls/15 litres applied twice over the top of cotton.

The experimental design, plot size and all other operations were similar to those in season one. However, during this season, all plots with the stack gene variety were cordoned off with appropriate strings, to avoid them being sprayed against bollworms. Sucking pests were controlled as in season one while bollworms were controlled from plots which did not have the stack gene cotton by sprays with Twiga Cyper at a rate of 120 mls /16 litres of water.

Results and discussions

Season one 2009/2010

Numbers of weed species and weed counts

The situations of weed species before and after Roundup application in NaSARRI and Mubuku are presented in Tables 1 and 2, respectively. There were big reductions in numbers of weed species counted a week after Roundup application, compared to numbers before. This was true for both broad-leafed weeds and grasses. The cocommon ones at Mubuku were *Caccia occidentalis, Caccia obtusifolia, Portulaca quadrifida, Portulaca oleraceae, Solanum incanum, Commelina benghalensis, Allium spp* and *Cyperus rotundus.* At NaSARRI *Spermacoce latifolia, Commelina benghalensis, Cyperus rotundus, Eleocharis companata, Paspalum* Spp., *Panicum maximum* and *Digitaria scalarum* were the common weeds observed after spraying Roundup. At NaSARRI, the biggest reduction was caused by application of 440 mls/15 litres (Table 1). Before Roundup application, numbers of both broad leafed weeds and grasses were not significantly different across treatments, as expected. Significant reductions occurred after herbicide application. At Mubuku, 220 mls/15 litres, especially on variety SG 125 RRFLEX, worked effectively like 440 mls/15 litres. The weeds observed after Roundup application, however, were weak, heading to die and could not offer any significant competition to the cotton crop.

Weed counts after Roundup applications were much lower compared to the situations before application (Table 3 for NaSARRI and Table 4 for Mubuku). Trends were similar to those of numbers of weed species as discussed above. These reductions enabled the cotton to take off and eventually out-compete subsequent weeds that sprung up in the course of the season, leading to acceptable yields.

Seed cotton yields

Yields of the transgenic cotton varieties and their isolines at NaSARRI were not significantly different from BPA 2002 under all the weed management treatments (Table 5). Weeds as a variable had no major impact on yields at NaSARRI suggesting that below a certain threshold of weeds, cotton performance was not affected. All the weed management treatments controlled weeds below that threshold. At Mubuku, however, all the "new" technologies out-yielded BPA 2002 under Farmers' practice. SG125RRF and its isoline SG125 performed better than DP110 and its isoline 99M03, which in turn performed better than the control, BPA 2002.

Preliminary conclusion for RRF trials for 2009

For NaSARRI, spraying the recommended rate of Roundup twice to SG 125 RR Flex was the best while for Mubuku, spraying SG 125 RR Flex twice with double the recommended rate was the be promising option. Generally, the technology of Roundup use on Monsanto's genetically modified cotton varieties worked under Uganda's conditions during this season, but their Economics could not be determined. This needed to be done once the price of Roundup Flex and seed costs were known. Further testing was recommended.

Season two 2010/2011

Numbers of weed species and weed counts

Numbers of weed species, both broad-leaved and grasses decreased significantly at both sites when sprayed with Roundup (Tables 6-7. This reduction permitted continuous cotton growth with less competition. At Mubuku broad-leafed weeds were more than grasses (Tables 7) before application of Roundup but during second scouting after application, the numbers of weed species were reduced to zero.

At NaSARRI a bigger count of grasses were recorded compared to broad leafed weeds before herbicide application but there was a big reduction after application. All the treatments were effective against the leaves (Table 8). Data in Table 9 for Mubuku shows that the numbers of both weed types had reached levels which would be unmanageable. This was because of delays in spraying. However, this scenario was reduced when the counts of both broad leafed weeds and grasses were reduced to zero. The large weed density that had developed provided a good surface for herbicide uptake, prevented direc losses to the ground and ensured effective action against all weeds. In all these cases, no damage to cotton was observed.

Seed cotton yields

Seed cotton yields for the two sites are presented in Table 10. At NaSARRI, the stack gene variety (SG125B2RF) hand weeded six times significantly out yielded BPA 2002. When sprayed with Roundup once or twice, yields were not significantly different from the controls. The same observation was true for the other transgenic variety and both isolines. They exhibited no superiority over BPA 2002.

At Mubuku, application of the recommended rate of Roundup twice, and double the recommended rate applied twice significantly increased yields of the transgenic varieties SG125RRFEX and SG125B2RF compared to the control BPA 2002 weeded three times an even six times.

These results for Mubuku confirm the observations made in 2009/2010 cotton season. They also point to the prospective success of herbicide use on transgenic cotton under Ugandan conditions and strengthen the need for introgression of the technology to the local cotton varieties in the country.

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Table 1: Number of weeds (species 0.5 m^{-2}) before and after Roundup application to cotton at NaSARRI, 2009

		Broad leafed species		Grass species		All species together	
Variety	**Weed management treatment**	**Before**	**After**	**Before**	**After**	**Before**	**After**
SG 125 RR Flex	220 mls/15 litres of Roundup sprayed once	6.5	2.0	6.3	3.8	12.8	6.0
SG 125 RR Flex	220 mls/15 litres of Roundup sprayed twice	7.3	3.8	6.0	4.3	13.3	8.0
SG 125 RR Flex	440 mls/15 litres of Roundup sprayed twice	6.8	1.0	5.8	2.3	12.5	3.2
DP 110 RF	220 mls/15 litres of Roundup sprayed once	5.8	2.8	6.0	4.3	11.8	7.5
DP 110 RF	220 mls/15 litres of Roundup sprayed twice	5.5	3.5	4.8	3.5	10.3	7.5
DP 110 RF	440 mls/15 litres of Roundup sprayed twice	8.5	1.0	7.3	1.5	15.8	2.3
	Mean	**6.7**	**2.3**	**6.0**	**3.3**	**12.7**	**5.8**
	Lsd	3.7	0.3	2.1	2.4	3.1	3.7
	Cv (%)	*37.0*	*48.8*	*23.8*	*48.7*	*16.5*	*42.8*

Table 2: Number of weed (species 0.5 m^{-2}) before and after Roundup application to cotton at Mubuku, 2009

		Broad leafed species		Grass species		All species together	
Variety	**Weed management treatment**	**Before**	**After**	**Before**	**After**	**Before**	**After**
SG 125 RR Flex	220 mls/15 litres of Roundup sprayed once	5.5	1.3	2.0	0.5	7.5	1.8
SG 125 RR Flex	220 mls/15 litres of Roundup sprayed twice	7.3	0.0	2.0	0.5	9.3	0.5
SG 125 RR Flex	440 mls/15 litres of Roundup sprayed twice	5.3	0.8	1.3	0.5	6.6	1.3
DP 110 RF	220 mls/15 litres of Roundup sprayed once	5.8	2.0	2.0	1.0	7.8	3.0
DP 110 RF	220 mls/15 litres of Roundup sprayed twice	4.8	0.8	1.3	0.5	6.1	1.3
DP 110 RF	440 mls/15 litres of Roundup sprayed twice	7.0	0.8	1.3	0.3	8.3	1.1
	Mean	**5.9**	**0.9**	**1.6**	**0.5**	**7.5**	**1.4**
	Lsd	2.9	1.8	1.5	0.8	2.7	1.9
	Cv (%)	*33.0*	*27.7*	*16.8*	*20.7*	*23.9*	*22.8*

Table 3: Numbers of weeds (counts 0.5 m^{-2}) before and after Roundup application to cotton at NaSARRI, 2009

		Broad leafed weed counts		Grasses counts		Total counts	
Variety	**Weed management treatment**	**Before**	**After**	**Before**	**After**	**Before**	**After**
SG 125 RR Flex	220 mls/15 litres of Roundup sprayed once	7.6	3.6	12.5	3.8	20.1	9.1
SG 125 RR Flex	220 mls/15 litres of Roundup sprayed twice	12.4	3.4	15.9	4.3	28.3	11.4
SG 125 RR Flex	440 mls/15 litres of Roundup sprayed twice	12.6	o.6	15.9	2.3	28.5	5.5
DP 110 RF	220 mls/15 litres of Roundup sprayed once	6.5	1.8	16.8	4.3	23.5	8.3
DP 110 RF	220 mls/15 litres of Roundup sprayed twice	11.8	3.4	13.5	3.5	25.3	8.9
DP 110 RF	440 mls/15 litres of Roundup sprayed twice	10.5	1.2	14.5	1.5	25.0	3.6
	Mean	**10.2**	**2.3**	**14.8**	**3.3**	**25.1**	**7.8**
	Lsd	0.4	0.3	7.1	2.3	11.7	5.7
	Cv (%)	*31.6*	*46.2*	*31.9*	*48.7*	*30.9*	*49.3*

Table 4: Numbers of weeds (counts 0.5 m^{-2}) before and after Roundup application to cotton at Mubuku, 2009

		Broad leafed weed counts		Grasses counts		Total counts	
Variety	**Weed management treatment**	**Before**	**After**	**Before**	**After**	**Before**	**After**
SG 125 RR Flex	220 mls/15 litres of Roundup sprayed once	29.5	1.5	6.3	0.5	35.7	2.0
SG 125 RR Flex	220 mls/15 litres of Roundup sprayed twice	27.8	0.25	9.0	1.8	36.7	2.0
SG 125 RR Flex	440 mls/15 litres of Roundup sprayed twice	34.0	1.75	3.3	0.8	37.2	2.5
DP 110 RF	220 mls/15 litres of Roundup sprayed once	31.8	2.75	5.0	1.0	36.7	3.8
DP 110 RF	220 mls/15 litres of Roundup sprayed twice	41.2	0.75	1.8	0.5	43.0	1.3
DP 110 RF	440 mls/15 litres of Roundup sprayed twice	54.0	0.5	1.8	0.3	55.7	0.8
	Mean	**36.4**	**1.25**	**4.5**	**0.8**	**40.9**	**2.0**
	Lsd	28.3	2.7	6.7	1.7	28.3	3.0
	Cv (%)	*51.6*	*30.0*	*16.5*	*24.8*	*46.0*	*24.8*

Table 5: Seed cotton yields (Kg/ha) under Confined Field Trials (RRF) at NaSARRI and Mubuku in 2009

Variety	**Weed management treatment**	**NaSARRI**	**Mubuku**
SG 125	Hand weed 6 times	1788.9	1842.6
SG 125	Hand weed 3 times	1922.2	2055.6
SG 125 RR Flex	Hand weed 6 times	1744.4	2055.6
SG 125 RR Flex	220 mls/15 litres of Roundup sprayed once	1370.0	1787.0
SG 125 RR Flex	220 mls/15 litres of Roundup sprayed twice	1800.0	1768.5
SG 125 RR Flex	440 mls/15 litres of Roundup sprayed twice	1677.8	1870.4
BPA 2002	Hand weed 6 times	1555.6	1324.1
BPA 202	Hand weed 3 times	1455.6	1379.6
99M03	Hand weed 6 times	1288.9	1842.6
99M03	Hand weed 3 times	1922.2	1731.5
DP 110 RF	Hand weed 6 times	1636.7	1731.5
DP 110 RF	220 mls/15 litres of Roundup sprayed once	971.1	1648.1
DP 110 RF	220 mls/15 litres of Roundup sprayed twice	1537.8	1601.9
DP 110 RF	440 mls/15 litres of Roundup sprayed twice	1444.4	1638.9
	Mean	**1579.7**	**1734.1**
	Lsd	556.4	273.7
	Cv (%)	24.6	11.0

Table 6: Number of weed (species 0.5 m^{-2}) before and after Roundup application to cotton at NaSARRI in 2010

Variety	Weed management treatment	Broad-leafed		Grasses		All species together	
		Before	**After**	**Before**	**After**	**Before**	**After**
SG125RRFLEX	220 mls/15 litres of Roundup sprayed once	6.3	0.3	6.8	0.8	13.0	1.0
SG125RRFLEX	220 mls/15 litres of Roundup sprayed twice	6.3	1.0	6.8	0.3	13.8	1.3
SG125RRFLEX	440 mls/15 litres of Roundup sprayed twice	8.0	0.0	8.0	0.0	16.0	0.0
SG125B2RF	220 mls/15 litres of Roundup sprayed once	8.0	0.8	8.5	0.8	16.5	1.5
SG125B2RF	220 mls/15 litres of Roundup sprayed twice	7.0	0.8	8.5	0.3	15.5	1.0
SG125B2RF	440 mls/15 litres of Roundup sprayed twice	7.8	0.3	8.5	0.5	16.3	0.8
	Mean	**7.2**	**0.5**	**8.2**	**0.4**	**15.7**	**0.9**
	Lsd	3.9	1.0	1.7	0.9	3.8	1.3
	CV (%)	*36.6*	*22.3*	*13.5*	*21.7*	*16.7*	*20.5*

Table 7: Number of weed (species 0.5 m^{-2}) before and after Roundup application to cotton at Mubuku in 2010

Variety	Weed management treatment	Broad-leafed		Grasses		All species together	
		Before	**After**	**Before**	**After**	**Before**	**After**
SG125RRFLEX	220 mls/15 litres of Roundup sprayed once	6.5	0.0	2.6	0.0	9.1	0.0
SG125RRFLEX	220 mls/15 litres of Roundup sprayed twice	5.8	0.0	1.9	0.0	7.6	0.0
SG125RRFLEX	440 mls/15 litres of Roundup sprayed twice	6.8	0.0	2.0	0.0	8.8	0.0
SG125B2RF	220 mls/15 litres of Roundup sprayed once	5.9	0.0	2.4	0.3	8.3	0.3
SG125B2RF	220 mls/15 litres of Roundup sprayed twice	6.9	0.0	2.0	0.0	8.9	0.0
SG125B2RF	440 mls/15 litres of Roundup sprayed twice	6.0	0.0	1.5	0.3	7.5	0.3
	Mean	**6.3**	**0.0**	**2.1**	**0.08**	**8.4**	**0.08**
	Lsd	2.1	0.0	0.9	0.3	2.3	0.3
	CV (%)	*23.1*	*0.0*	*31.5*	*11.9*	*18.3*	*11.9*

Table 8: Numbers of weeds (counts 0.5 m^{-2}) before and after Roundup application to cotton at NaSARRI in 2010

Variety	Weed management treatment	Broad-leafed		Grasses		All species together	
		Before	**After**	**Before**	**After**	**Before**	**After**
SG125RRFLEX	220 mls/15 litres of Roundup sprayed once	13.6	0.5	34.4	0.5	48.0	1.0
SG125RRFLEX	220 mls/15 litres of Roundup sprayed twice	16.0	0.5	22.4	0.3	38.5	0.8
SG125RRFLEX	440 mls/15 litres of Roundup sprayed twice	12.9	0.0	23.3	0.0	36.4	0.0
SG125B2RF	220 mls/15 litres of Roundup sprayed once	17.4	0.5	24.3	0.5	41.6	1.0
SG125B2RF	220 mls/15 litres of Roundup sprayed twice	10.6	0.8	23.3	0.1	33.9	0.6
SG125B2RF	440 mls/15 litres of Roundup sprayed twice	10.4	0.1	21.3	0.3	31.3	0.4
	Mean	**13.4**	**0.4**	**24.9**	**0.3**	**38.3**	**0.6**
	Lsd	0.3	0.7	0.3	0.5	26.9	1.0
	CV (%)	*20.9*	*17.2*	*13.2*	*15.7*	*46.6*	*18.2*

Table 9: Numbers of weeds (counts 0.5 m^{-2}) before and after Roundup application to cotton at Mubuku in 2010

Variety	Weed management treatment	Broad-leafed		Grasses		All species together	
		Before	**After**	**Before**	**After**	**Before**	**After**
SG125RRFLEX	220 mls/15 litres of Roundup sprayed once	86.4	0.0	33.7	0.0	119.7	0.0
SG125RRFLEX	220 mls/15 litres of Roundup sprayed twice	96.5	0.0	34.7	0.0	131.3	0.0
SG125RRFLEX	440 mls/15 litres of Roundup sprayed twice	88.7	0.0	53.0	0.0	141.8	0.0
SG125B2RF	220 mls/15 litres of Roundup sprayed once	106.0	0.0	39.0	0.5	145.0	0.5
SG125B2RF	220 mls/15 litres of Roundup sprayed twice	96.7	0.0	81.5	0.0	178.3	0.0
SG125B2RF	440 mls/15 litres of Roundup sprayed twice	106.2	0.0	52.0	0.3	158.3	0.3
	Mean	**96.7**	**0.0**	**49.0**	**0.1**	**145.7**	**0.1**
	Lsd	38.1	0.0	71.8	0.6	94.9	0.6
	CV (%)	*26.2*	*18.3*	*50.4*	*13.2*	*43.2*	*13.2*

Table 10: Seed cotton yields (Kg/ha) under Confined Field Trials (RRF) at NaSARRI and Mubuku in 2010

Variety	Weed management treatment	NaSARRI	Mubuku
SG125	Hand weed 6 times	1822.2	3306.5
SG125	Hand weed 3 times	1662.2	2816.7
SG125RRFLEX	Hand weed 6 times	1818.9	2744.4
SG125RRFLEX	220 mls/15 litres of Roundup sprayed once	1010.0	2090.7
SG125RRFLEX	220 mls/15 litres of Roundup sprayed twice	1015.6	2950.0
SG125RRFLEX	440 mls/15 litres of Roundup sprayed twice	1265.6	2873.1
SG125B2RF	Hand weed 6 times	1983.3	3039.8
SG125B2RF	220 mls/15 litres of Roundup sprayed once	993.3	2220.4
SG125B2RF	220 mls/15 litres of Roundup sprayed twice	1611.1	3083.8
SG125B2RF	440 mls/15 litres of Roundup sprayed twice	1463.3	2556.5
BPA2002	Hand weed 6 times	1462.2	2384.3
BPA2002	Hand weed 3 times	1495.6	2290.7
	Mean	**1466.9**	**2696.4**
	Lsd	403.5	631.3
	CV (%)	*19.1*	*16.3*