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ONIONS — FROM A POSSIBILITÉ TO A REALITY IN BARBADOS

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Barbados imports over three million pounds of onions per year at a cost of approximately $ 350,000 E. C.. The CARIFTA territories as a whole import approximately 26.5 million pounds worth nearly two million dollars. About 1,500 acres of onions are necessary to satisfy this market. The prospects for large scale production of onions and other vegetable crops in Barbados are good because of favourable soils. Part of the island is covered by black calcareous clay soils with a friable surface structure, so that good tilth is combined with a high moisture retaining capacity. This combination of properties is uncommon.

In July 1966 a paper was presented by JEFFERS and GOODING at the Caribbean Food Crops Society Conference entitled « Onions — a possibility for Barbados ». A small trial laid down by GOODING which yielded at the rate of 15 tons per acre was described.

VARIETIES

Toward the end of 1966 onion variety trials were carried out by JEFFERS, WILLIAMS and ALLEYNE at the Ministry of Agriculture stations. The varieties tested were Granex F1 Hybrid, Texas Early Grano 502, Yellow Bermuda, Red Creole and Crystal White Wax. The yields of all varieties were good and an opportunity was taken to observe consumer reaction. Based on this and other factors the two varieties, Granex F1 Hybrid and Texas Early Grano were selected for further work. The other varieties were dropped from the programme for various reasons. Yellow Bermuda produced a large number of split bulbs which were particulary prone to rot. In the case of Red Creole and Crystal White Wax, when exposed for sale alongside of the yellow varieties the consumer selected the latter first, and when supplies were exhausted selected the Red Creole. It was only when neither the yellow varieties or Red Creole were available that the Crystal White Wax was taken. Recently, in the 1969 crop the Grano and Granex varieties have not kept well in storage, and it has been decided to bring Red Creole back into the programme on account of its reputation as good storage variety. Tropicana another red variety is also undergoing trials with a view to storage.

Ministry of Agriculture, Barbados.

TIME OF PLANTING TRIALS

Trials were conducted by JEFFERS, WILLIAMS and ALLEYNE to examine the effect of date of planting on yield during the period October to March. Bulbing occurred at a progressively earlier stage of growth throughout this period and yields decreased five fold. Similar planting distances were used throughout, and the yield decrease occurred because the individual bulbs became progressively smaller. Closer spacing and an increase in population density is necessary in order to maintain the higher yields. October plantings give a relatively smaller number of large onions, while later plantings should provide a greater number of smaller onions.

REQUIREMENTS POR BULBING

Bulb initiation in onions depends on daylength, temperature and stage of growth.

HEATH (1969) and others worked out the minimum daylength requirements at constant temperatures and found that it varied from 12 to 16 hours for varieties selected at different latitudes. The minimum daylength requirement was less at higher temperatures (over the moderate range explored up to 27° C) ; that is both longer days and higher temperatures resulted in more rapid bulbing, which in turn was followed by more rapid ripening.

In Barbados during 1968-1969, the Granex F1 Hybrid and the Texas Early Grano varieties sown in October did not bulb in the period mid November to the end of January ; that is when the daylength was less than 11.5 hours. Onions sown in the autumn which have not initiated bulbs before mid November will therefore continue to grow until the end of January before doing so, and the plant will be large when bulbing commences. These large plants then produce large bulbs. Onions which are sown later have a shorter growing period before bulbing is initiated and are therefore smaller.

No experimentation has yet been undertaken on planting outside the period October to March but the following hypothetical predictions can be tested :

1. With August or September plantings, if bulbing is initiated by mid November, the bulb will continue to develop and will mature in January or early February. If bulbing is not initiated by mid November then oversized bulbs will be produced in late March.

2. The longer the day, the earlier, the stage of growth at which bulbing commences and the smaller the bulb. June sowings would therefore be expected to produce the smallest bulbs. It is not yet known if these would be marketable, but there is some evidence (from a garden plot) that satisfactory onions were produced in Barbados in 1968 from June sowings.

3. Varieties with a slightly longer minimum daylength requirement would allow sowings to be made in February, March and April to supply a market when onions are internationally scarce (i. e. in June, July and August) when the price is high.

4. Experience with the Granex and Grano varieties indicates that under average growing conditions, the optimum date of planting for a variety is about 12 weeks before it starts to bulb. If a variety was found which began to bulb on May lst, for example (daylength 12 hours 36 minutes), then it shouldbe planted on February lst.

Much more empirical experimentation is necessary to test these predictions since this may lead to all-the-year-round production, one of there maining obstacles in plans for expansion of the onion industry in Barbados.

Commercial production of onions

In October 1967 Jeffers, Williams and Alleyne laid down two one acre costing trials at Sayes Court and Bullens using the above two varieties. Half of each trial was direct-seeded and planted 4 rows per 5 ft. ridge and the other half was transplanted using thinnings. The results showed that where high yields were obtained (as at Sayes Court where 15 tons were harvested from one acre), a good profit could be expected However, the operations of sowing, transplanting and thinning were done by hand and only a small number of workers could be trained to carry out these relatively skilled operations.

For large scale production seeding must be mechanised and transplanting and thinning operations must be eliminated. This is accomplished by precision seeding techniques. Eavis introduced a mechanical tractor-mounted 5 row precision seed drill into Barbados in 1968, and the total production of onions was consequently increased from 30 tons in 1968 to approximately 200 tons in 1969. A further increase is planned for 1970.

The seed drill

In the type of seeder chosen, individual seeds are picked up by holes in a moving rubber belt. They are discharged near ground level into a groove made by a coulter in the soil surface, and are covered by a drag-bar and a press wheel. The drill can also be used to sow cotton, brassicas, carrot, cucumber, lettuce, corn, melon, peanuts, peppers, red beet, small beans, tomato, turnips and other crops. The type of belt, choke and spring base necessary to sow a given crop at the desired spacing is determined by the manufacturer from a sample of the seed provided by the grower. The necessary alterations to each seed drill can be made in a few minutes. As an alternative to the belt type of precision seed drill, the plate type can be used in which holes in circular metal discs select the individual seeds. Both types of drill will deliver regular shaped seed singly at the desired spacing in the row ; with onions the seeds were delivered singly at intervals of one inch and subsequent thinning was not therefore necessary. With melons, for instance, the drill has been used to sow seed singly at nine inch intervals.

In many areas of the world good results are obtained with seed drills which are not of the precision seed spacing type, but careful setting is necessary and although cheaper these simpler drills were rejected on the grounds that inexperience in their use might lead to crop failures.

Ancillary cultivation equipment

Mechanical seed drills are not likely to work satisfactorily unless special methods are used in the final stages of land preparation. The soil must be levelled, refined and

rolled. The first two operations are carried out by using a *levelling spike-tooth harrow*. At the front and rear of this tool, 13 ft. wooden beams are mounted to move the soil from high spots into depressions and six inch metal spikes break up clods and create a fine surface condition. The final operation before seeding is carried out by a Cambridge roller. Its purpose is to crush clods and create sufficient compression of the surface soil for mechanical planting.

Selection of site

In Barbados the black montmorillonite clays (soil types mapped as 10, and 30) and the montmorillonite/kaolinite mixtures (40) are best suited to onion production. Of the soil types tried, those least suited are the red sands (70) in St. Peter and St. James and the chalk and alluvial soils of the Scotland District. The sands and chalk soils require almost daily irrigation in dry weather whereas the black soils will produce fair crops without any irrigation from October plantings. The alluvial soils of St. Andrew produce a surface cap especially after irrigation, which tends to prevent germination.

A level site which does not become waterlogged is most suitable. An area not susceptible to erosion should be selected.

There should always be a three year « rest period » between successive onion crops as a precaution against the build up of nematodes and diseases such as white rot. If a shorter cycle is used these pests and diseases would undoubtedly ruin an onion industry in Barbados as they have done in other countries (Lincolnshire, England).

Although onions were produced successfully without irrigation at six sites during 1968-1969, the risk of crop failure is greater and the yields are less than on sites with irrigation. The quantity of water needed to produce a large increase in yield is small and irrigation facilities are a good investment.

Where possible the site should be close to the plantation yard as frequent inspections of the crop are necessary for efficient pest control.

Land preparation

Land which is taken out of sugar cane can present a problem because the presence of trash, stumps and rocks interfere with the mechanical planting operation. The following recommendations have been issued for the guidance of extension staff and growers and they result in a soil surface which is free from stumps, trash and rocks at the time of planting.

First preparation

1. Burn the trash after harvest.
2. Use a tractor rotavator to cut up the stumps.
3. Invert the soil with a mouldboard plough in order to bury the stumps and trash.
4. Select a day when the soil is moist but not wet (e. g. three or four days after rainfall) and use the levelling spike-tooth harrow. At the same time pick up rocks and place on the bed of the harrow and then deposit them off the field.

These operations can be carried out in May, June or July for a field coming out of sugar cane. It is then best to fallow the land until the autumn. Any weed growth during this period should be controlled by using the spike-tooth harrow and the weed population in the crop can be subsequently much reduced by this treatment.

Final preparation

This depends on the conditions of the land near planting time but if it is clean and not compacted the following two operations should suffice.

5. Use the spike tooth harrow and by a system of *markers* define straight pathways, making sure that the tractor wheels always run in these pathways. It is *most important* not to allow wheel marks at this stage on land which will constitute the onion bed.

6. Using a 4 ft. 6 in. Cambridge roller with the tractor following in the previous wheel marks finally define beds and pathways.

If the fallowed land is level and in good condition operation 5 can be omitted. Where the soil is in poor condition (e. g. compacted after heavy rainfall), it may be necessary to use the rotavator again. It is very important to avoid wheel marks during this operation ; the rotavator must be offset. After rotavating operations 5 and 6 should be carried out.

Row widths and pathways

The individual seeder units are mounted on a tool-bar which is attached to the three-point linkage of the tractor, and the row widths are adjustable from eight inches upwards. The row widths used in the 1968-1969 experiment were nine inches apart and five rows were straddled by the tractor wheels, the wheel marks delineating 24 inch pathways between the beds.

The recommendation issued for the 1969-1970 crop is for six rows eight inches apart per bed, with 24 inch pathways between the beds. The tractor wheels should be spaced 66 inches centre to centre which is the spacing used in sugar cane.

The extra row and decrease in row spacing from nine to eight inches will result in a 12 % increase in population density and is expected to be reflected as a 12 % increase in yield.

If row widths are too narrow there are problems with both mechanical and hand weeding, and eight inches is considered the minimum practicable. There is no doubt that further increases in plant population would result in greater yields and when the weeding problem can be solved by methods other than hoeing there may be a further justification for decreasing the row widths.

A decrease in the width of some of the pathways is also desirable. The purpose of pathways is to allow access for hoeing and spraying, and they act as surface drains. If a tractor boom sprayer is used it is important that the pathways are wide enough to allow access up to harvest, when the bulbs are swollen and the effective pathway width reduced. With a boom sprayer covering five beds, only every fifth bed has to be used by the tractor and it is advantageous to reduce the width of the other pathways to 15 inches, which is the minimum width necessary to allow entry forh and weeding.

This arrangement would result in another 12 % increase in population density and a corresponding yield increase, but it is only recommended where a skilled tractor drive is available to carry out the rather complicated operation. These narrow pathways could be entered if the tractor is fitted with 6 or 8 inch narrow wheels and mechanical hoeing might thus still be possible using this arrangement.

Drainage

The pathways act as surface drains and although shallow they dealt satisfactory with three inches of rainfall falling in one day at the end of January 1969. Sufficient depth is created by the passage of the tractor if the soil conditions are fairly wet. More crop damage occurred after heavy rainfall where the pathways were deep than where shallow due to a greater amount of erosion from the outside rows of the bed. Raised beds are not therefore recommended. In the case of very intense rainfal the crop will be washed out whether on raised beds or not and this is one of the risks to be understood.

At Graeme Hall water accumulated in low places and temporarily flooded the crop. Underground plastic pipe drainage has now been installed and similar drainage schemes are currently being undertaken by the Ministry of Agriculture as a free service.

The drilling operation

The drill should be checked prior to seeding making sure that the correct bulbs, chokes and spring bases are fitted ; that the spring base is inserted in the correct manner ; that the seeder units are properly fitted ; that the correct pulley wheels are used for the spacing desired ; and the tractor operator should be told the correct m. p. h. to drive. The top link should be adjusted so that the tripod is in the vertical position when in work, and the front coulter shoes should be adjusted to give the correct sowing depth (one inch for onions).

The tractor operator is provided with a flashing light signal on the dash board which informs him if the internal mechanism of a drill unit is not working. There is also a signal from one drill unit which indicates when the hopper is nearly empty of seed. In spite of these refinements it is still necessary under local conditions to have a reliable person walking behind the drill to check the operation. This person must clear stumps or trash which jam the front wheels of the drill and a crop failure will result if this is not done efficiently. If the wheels are jammed and lifted out of position the seed will be deposited on the soil surface instead of at the correct depth. Under moist conditions the rear wheels become jammed by soil and this must also be periodically attended to.

Under average conditions it is possible to drill one acre per hour but where stumps and trash are present time is wasted out of work. The recommended speed of drilling is between 2 and 3 miles per hour depending on the belt and pulley used.

Care must be taken to see that none of the hoppers runs short of seed.

THE 1968-1969 EXPERIMENTS

The following list indicates the ten sites used in 1969-1969 for experiments in onion growing using the above methods.

Site	Parish	Soil type	Acreage	Date of sowing	Date of harvest	Yield tons per acre	Irrigation
Graeme Hall Agricultural Station	Christ Church	30-34 montmorill. clay	Total = 10 acres (see below)			Total = 46.0 T	
	1.		1.5*	23 Oct.	20 Mar.	7.1	once only
	2.		4.0	11 Dec.	14 May	5.0	yes
	3.		3.5	18 Dec.	10 May	1.9	none
	4.		1.0	20 Dec.	5 May	6.2	yes
	5.		.18	11 Dec.	6 May	15.0	yes
Plantations							
	A. St-Philip	10 mont. clay	1.0	28 Oct.		none (eaten by caterpillars)	
	B. St-Philip	ditto	.75	12 Nov.	29 Mar.	5.06	none
	C. Christ Church	30 mont. clay	.85	18 Nov.	9 Apr.	2.22	none
	D. Christ Church	40 Kaol. and montmoriclay	.43	18 Nov.	9 Apr.	5.04	none
	E. Christ Church	40	.76	19 Nov.	9 Apr.	7.34	none
	F. Christ Church	40	.50	19 Nov.	10 Apr.	5.10	none
	G. St-Peter	70 red sand	2.40	14 Jan.	1 June	2.31	yes
	H. St-Andrew (Haggatts)	173 alluvion	1.0	17 Jan.		none (poor germination due to capping)	
	I. St-Lucy (Cluffs)	10	10.0	24 Nov. to	27 Mar. 14 Apr.	10.0 (total = 100 T)	yes

Note : Ten acres were originally planted at Graeme Hall on 23-25th Oct. but only 1 1/2 acres survived a caterpillar attack (see text) and the remainder was redrilled in December.

GERMINATION AND RAINFALL

There were no germination failures under the rainfall conditions existing during October, November and December 1968 (see Fig. 1). It was convenient to sow under the driest conditions available and rely on later rainfall to assist germination. It is unusual to experience more than 14 consecutive dry days during these months and the seed can remain unharmed for a longer period of time if germination has not commenced. Plantations C. D, E, and F experienced 14 dry days after sowing and almost perfect germination was subsequently obtained.

At a later stage of growth when the seed has chitted, or in the seeding stage, it is estimated that 20 days might be critical on the black soils so it is possible that drought may sometimes make replanting necessary where no irrigation is available. The frequency of occurrence of 20 consecutive dry days at any particular site can be obtained by examining rainfall records.

The chief operations necessary during the growth of the crop are weed control, pest control, fertiliser application and irrigation. These are now discussed.

WEED CONTROL

Chemical weed control was almost completely in-effective with the partial exception of contact pre-emergence measures.

1. *Contact pre-emergence weedkiller trials*

The aim is to scorch those weeds which emerge before the crop germinates. Under wet conditions onions germinate in seven days and many weeds take a longer time (e. g. grasses). Some success was obtained with Paraquat (e. g. Grammoxone-W) with the fast germinating weeds by spraying one day before the emergence of the onions. Due to wet weather, it was not possible to use a tractor or wheel type sprayer and this is a problem which may often recur. The subsequent saving in hand weeding costs if weed seedlings are killed at this stage may be very considerable, and a great deal of effort is worthwile to select the correct day for spraying, which should be as late as possible but not after the onions have emerged.

More weeds may be killed if onion drilling is delayed for several days after the final seed bed preparation, due to a longer period for weed germination. The risk of loosing an opportunity for sowing in dry weather must be considered against the benefits likely to be accrued as a result of better weed control.

2. *Residual pre-emergence weedkillers*

These are designed for application before germination and will kill susceptible weeds as they come through the soil surface during the subsequent post germination period. Some also act as contact pre-emergence weedkillers. The following chemicals in this group were applied one day before germination on trial plots of quarter of an acre.

Pre-emergence applications

Chemical	Rate of application per acre	Volume of diluted spray per acre	Efficacy of control
1. Tok E	6 pints	50 gallons	Weeds germinated equally well on treated and on untreated plots. Ineffective.
2. Herbon White	3 pints	70 gallons	Ditto
3. Ramrod	4.75 lbs	50 gallons	Ditto
4. Alicep	3 lbs	50 gallons	Ditto
5.	4 lbs	50 gallons	Ditto
6.	5 lbs	50 gallons	Ditto
7. Dacthal	1 1/2 lbs	50 gallons	Ditto
8.	2 3/4 lbs	50 gallons	Ditto
9.	3 1/2	50 gallons	Ditto

3. *Post-emergence weedkiller trials*

The following chemicals were sprayed on plots of 1/8 acre six weeks after planting at Graeme Hall, when the onions were at the 4 leaf stage.

Post-emergence applications

Chemical	Rate of application per acre	Volume of diluted spray per acre	Efficacy of control	Damage to the onions
1. Herbon Red.....	4 pints	60 gallons	*Very poor	None
2. Herbon Yellow	1 gallon	60 —	—	—
3. — —	5 —	60 —	—	—
4. — White	4 pints	60 —	—	—
5. Alicep	3 lbs	60 —	—	—
6. Dacthal	1 1/2 lbs	60 —	—	—
7.	2 1/2 lbs	60 —	—	—
8.	3 1/2 lbs	60 —	—	—
9. Tok E	6 pints	60 —	—	—
10.	12 —	60 —	Fair	Considerable
11. Sulphuric acid	10 % solution	16 —	Did not kill the grasses but killed other weeds	Considerable

* Weeds often scorched but not killed.

It is clear from the above results that these weed killers are not effective, and were not selected for Barbadian weeds. In most cases there was some scorching of the leaves but the weeds usually recovered and hand weeding was never completely eliminated. The following weeds were recorded.

Rating		Common name	Botanical name
***	1.	Rice grass	*Brachiaria eruciformis*
	2.	Spinach	*Amaranthus dubius*
	3.	Prickly caterpillar	*Amaranthus spinosus*
	4.	Devil's grass	*Cynodon dactylon*
	5.	Not known	*Kalstroemia pubescens*
	6.	Pussley or Purslane	*Portulaca oleracea*
	7.	Water weed	*Spigelia anthelmia*
	8.	Rabbit vine	*Teramnus labialis*
	9.	Lion's tail	*Leonotis nepetifolia*
	10.	Not known	*Borreria laevis*
	11.	Chickenweed	*Portulaca quadrifida*
*****	12.	Milky weed	*Euphorbia* sp.
	13.	Burn-mouth vine	*Rhynchosia minima*
****	14.	Seed-under-leaf	*Phyllanthus fratenus*
*****	15.	Hair grass	*Leptochloa filiformis*
	16.	Nut grass	*Cyperus rotundus*

(with acknowledgements to Mr. Merland BURKE and Mr. Graham GOODING)

HAND WEEDING

Apart from the harvesting operation, hand weeding was the major cost in the production of the crop. The hours (women and men) needed per acre during the five month growth period were :

Per acre

Graeme Hall	400 man hours
Plantations B, C, D, E & F	315 man hours (average for five sites)
Cluffs	117 man hours

The low figure at Cluffs is the result of early control of weed seedlings and good supervision of workers. At Graeme Hall the failure of the first sowing due to caterpillar attack, added six extra weeks to the duration of the crop and therefore increased the hours spent weeding.

The major part of the weeding was carried out by women who were provided with light six inch draw hoes. Other hoes should be tried experimentally in 1970, such as the Dutch hoe, and the « Planet Junior ».

Tractor-mounted steerage hoes may also be used. For satisfactory operation in rows eight inches apart, however, the soil conditions must be near perfect, free from trash, rocks and clods and very level.

Special measures should be taken before planting to control the weeds on headlands. To secure effective permanent weed control it is best to combine weedicide application with rotavation. It may be difficult to spray weedicides on the headlands after the crop is established because of the danger of drift. At Graeme Hall grass seeds from the perimeter of the field caused a problem on the windward side.

Pest control

Pest control was the chief problem encountered in the 1968-1969 crop and the failure of several chemicals to control pests as expected nearly led to the abandonment of the project. Satisfactory methods have now been developed but extreme vigilance is very important.

Description of the pest damage

1. *Leaf-eating caterpillars*

These first appeared at Graeme Hall exactly seven days after germination. At 5.00 p. m. on the sixth day no caterpillars were seen ; at 7.30 a. m. on the seventh day nearly every onion seedling was colonised. The caterpillars are very small (2 to 3 mm in length), greenish in colour and they feed at the extreme tip of the seedling leaves. Damage seedlings can be quickly identified because of the absence of the terminal « hook », only the vertical part of the seedling remaining. The seedlings are quickly consumed on account of their small size.

The moths lay eggs in clusters on the first leaf soon after germination and these eggs require an incubation period before hatching. Protective spraying is not effective since considerable damage occurs before the caterpillars are destroyed by the poisoned leaves, and it is therefore essential to secure a direct hit with the

spray on the caterpillars on the day of hatching. This is essential (even at the weekend).

New generations of the insect appear throughout the growth ot the crop and later the caterpillars enter the hollow leaves and feed on the inside tissues. As the crop nears maturity the caterpillars sometimes feed within the crown of the bulb and this damage can lead to premature rotting.

The control of this pest is therefore of prime importance.

2. *Leaf miner*

Hollow tunnels appear in the middle tissues of the leaf and these are contorted and take on a translucent appearance. The larvae can be seen feeding at the end of the tunnels. The pest occurred about two weeks after germination and there after throughout the life of the crop. The damage starts at the tips of the leaves which become white and have a crinkled appearance and these symptons quickly advance toward the base of the plant. Where no control measure are implemented the plant is killed.

3. *Onion thrips*

An infestation can build up at any stage of growth but in the experiments an early outbreak was probably prevented by the D. D. T. spray used for caterpillar control. D. D. T. spraying was stopped six weeks before harvest and thrips became a problem in the maturing onions. The individual thrips are just visible to the naked eye and several hundred can be counted on a small area of the leaf surface. They are pink sucking insects and are often concealed in the tightly packed leaves, where they are partially protected from the spray.

The leaves become freckled with small white spots and eventually the whole leaf looses its green colour. Infected areas in the field can be indentified at a distance by the whiteness of the vegetation and these areas quickly enlarge so that a small infestation can spread over several acres within a few days.

4. *Cutworms*

The mature onions at Graeme Hall were windrowed on the soil surface for two to three weeks after pulling in order to allow the tops to dry to assist ripening. Circular bites of approximately 1/4 inch in diameter appeared in the onion bulbs as a result of cutworm attack and subsequently rots occurred. No control measures could be implemented at this stage. Unless a method can be found to prevent such looses it is not advisable to windrow onions in the field.

THE EVOLUTION OF A SPRAYING PROGRAMME

The list which follows shows how a spraying programme was developed and how the successful later plantings were achieved as a result of the earlier failures and experience gained at Graeme Hall :

Date	Site	Material	Rate per acre (in 16 gallons of water)	Efficacy of control	Pest which desired to control
Nov. 8	G. H.	Trichlorphon (= Dipterex)	1 1/2 lb	Very poor	Leaf eating Caterpillars
12	G. H.	Dipterex plus Agral 90 wetter	3 lb	—	Caterpillars
15	G. H.	Dipterex Agral 90 wetter	3 lb	—	Caterpillars
19	G. H.	Dipterex Agral 90 wetter Carbaryl (= Sevin)	3 lb 1 1/2 lb	—	Caterpillars
22	G. H.	Dipterex Carbaryl (= Sevin) Agral 90 wetter	3 lb 3 lb	— —	Caterpillars Caterpillars
26	G. H.	Ditto	ditto	—	Caterpillars

A this stage 8 1/2 acres out of ten were decimated at Graeme Hall. Redrilling was carried out from December 11th. Meanwhile, onions at plantations A and B were attacked by the same pest. Those on plantation A were wiped out within two days (ten days after germination) but the caterpillars remaining were discovered to be susceptible to D. D. T. At plantation B, D. D. T. was immediately sprayed as follows but the application was about 8 hours too late and the population density was reduced to approximately half-the yield would probably have been doubled if spraying had been carried out 8 hours earlier.

Nov. 30	Plt. B.	D. D. T. (Arkatene)	4 pints	Good	Caterpillars

On plantations A, B, C, D, E, F, D. D. T. was thereafter sprayed weekly up to six weeks before harvest. Other sprays were later introduced to control leaf miner and thrips.

Dec. 9	Cluffs	Chlordane dust	3 lb	Used as a preventative measure but failed to control a later attack	Caterpillars
17	—	—	3 lb	ditto	—
19	—	Dieldrin	1 1/2 pint	very bad attack; emergency measure fair control but not complete	Caterpillars
24	—	D. D. T. (Arkatene) Triton × sticker	4 pints 1/4 pint	Good	—

Thereafter D. D. T. was sprayed regularly up to mid February at Cluffs.

The second major pest was first noticed at Plantation B and at Graeme Hall on the October sown onions, on December 20th. This was LEAF MINER.

Dec. 23	Plt. B.	Bidrin	6 fl. oz.	Good Good	Leaf miner Caterpillars
23	G. H.	D. D. T. Dimethoate (= Rogor or Perfekthion)	4 pints 4 fl. oz.	Good Good	Caterpillars Caterpillars Leaf miner

Subsequently, either of the above two treatments was used at all sites at weekly intervals.

The third major pest thrips occurred first at Graeme Hall after D. D. T. spraying had been dropped and replaced by Bidrin. Thrips were noticed on the most mature onions on 20th February and doubling the concentration of Bidrin failed to control them.

Feb. 27	G. H.	Bidrin and wetter	12 fl. oz.	Good Good Very poor	Caterpillars Leaf miner Thrips
28	G. H.	Malathion and wetter	1 1/2 pints	Good but only for two days	Thrips

This treatment was repeated twice weekly at Graeme Hall until one week before harvest and was subsequently introduced to the spraying programme at Cluffs where a small outbreak was prevented from becoming a major problem. Thrips damage was also severe at all the other sites, but occurred too late to seriously affect yields.

Pest control recommendations for the 1969-1970 crop

As a result of the above experience the following recommendations have been issued for use in the 1969-1970 crop.

1. Inspect the crop daily for signs of caterpillars and on the Fourth day after germination spray with.

		Per acre
D. D. T. 25 % liquid (e. g. Arkatene or D. D. T. E-25)	4 pints	30 gallons of diluted spray
Sticker (e. g. Chevron or Triton X).....	1/4 pint	

2. Continue to inspect the crop each morning and evening and at the first appearance of small newly hatched caterpillars (2-3 mm). Repeat the above treatment.
3. Repeat again Three days after the first sign of caterpillars or in any case one week after the first application.
4. Repeat weekly until six weeks before harvest.
5. When Leaf miner tunnels appear combine the above spraying with Dimethoate (e. g. Rogor or Perfekthion) as follows.

		Per acre
D. D. T. 25 % liquid (e. g. ARKATENE or D. D. T.-E 25)	4 pints	30 gallons of diluted spray
Dimethoate (e. g. Rogor or PERFEKTHION)	3 fl. oz.	
Sticker (e. g. CHEVRON or TRITON X)	1/4 pint	

6. Thereafter REPEAT WEEKLY until six weeks before harvest.

7. In the daily inspection of the crop watch for thrip damage, especially after D. D. T. spraying has been stopped and spray as follows TWICE a week until 4 days before harvest.

		Per acre
Malathion	3 pints	30 gallons of diluted spray
Sticker (as above)	1/4 pint	

Further experimentation is needed in order to attempt to find chemicals which are less toxic or persistent than those listed above and the recommendations set out should be reviewed in the light of further work.

The cheapest method of application is by tractor-mounted boom sprayer. However, the tractor cannot pass through the field in wet weather and knapsak sprayers must always be available for such emergencies. Tractor-mounted sprayers can apply the chemical at higher volume than knapsack sprayers and the control is better. Careful supervision of spraying is necessary where knapsacks are in use to ensure the crop is completely covered.

FERTILISER REQUIREMENTS

Two hundred and forty three combinations of NP, NK, or PK were laid down in an experiment at Graeme Hall using a non-randomised systematic design as follows :

Onion yields at graeme hall

(Fertiliser experiment)
(tons per acre)

BLOCK 1

Super-phosphate (cwt/acre)

Sulphate of ammonia (cwt/acre)	0	1	2	3	4	5	6	7	8	Mean
0	12.2	12.0	14.1	14.3	14.3	13.5	13.0	10.3	11.2	12.8
1	12.6	13.3	10.9	13.1	13.5	15.2	13.9	9.7	10.1	12.5
2	14.9	12.6	11.1	18.1	15.6	14.9	11.1	7.8	6.2	12.5
3	10.5	7.8	9.5	12.8	13.5	12.8	16.6	10.5	6.9	11.2
4	9.0	6.7	14.1	14.5	14.5	16.4	12.8	12.2	10.9	12.3
5	15.1	9.3	10.7	13.0	9.3	20.7	16.0	5.7	10.1	12.2
6	11.4	10.1	14.5	12.2	13.7	15.2	14.5	10.7	10.3	12.5
7	10.3	11.0	15.6	10.3	16.0	16.4	16.6	13.9	11.8	13.5
8	6.1	7.2	16.1	15.2	11.4	13.1	13.5	9.1	8.4	11.1
Mean	11.3	10.0	13.0	13.7	13.5	15.4	14.2	10.0	9.5	12.3

(muriate of potash constant at 200 lbs/acre)

BLOCK 2

Muriate of potash (cwt/acre)

Sulphate of ammonia (cwt/acre)	0	1	2	3	4	5	6	7	8	Mean
0	12.0	10.1	12.4	16.3	16.6	16.6	14.3	13.7	14.3	14.0
1	12.2	11.6	15.1	12.0	14.3	13.7	15.2	11.8	14.1	13.3
2	13.7	14.5	15.4	15.8	15.8	16.6	16.6	14.3	15.1	15.5
3	13.5	14.7	15.8	16.6	16.0	16.0	16.6	9.7	12.4	14.6
4	15.4	14.1	15.5	16.3	16.4	16.0	16.6	15.1	15.2	15.6
5	11.2	12.2	15.1	16.6	17.0	14.7	15.4	14.8	16.4	14.8
6	13.0	12.2	10.1	18.3	17.1	17.0	15.2	15.4	15.0	14.8
7	9.1	15.0	16.8	16.4	16.6	17.0	16.6	13.9	14.1	15.0
8	15.9	16.6	16.6	16.4	16.8	12.3	16.6	15.1	8.9	15.0
Mean	12.9	13.4	14.8	16.1	16.3	15.5	15.9	13.8	13.9	14.7

(Superphosphate constant at 200 lbs per acre)

BLOCK 3

Superphosphate (cwt/acre)

Muriate of potash (cwt/acre)	0	1	2	3	4	5	6	7	8	Mean
0	13.4	17.0	16.1	16.2	11.8	15.6	16.2	15.2	16.0	14.7
1	13.0	15.6	13.1	16.6	15.4	16.3	16.4	15.8	17.7	15.5
2	15.2	16.6	14.7	16.6	14.6	16.6	15.5	16.3	16.2	15.8
3	16.4	14.4	16.3	14.4	15.2	16.2	17.1	13.5	16.8	15.7
4	18.8	16.4	18.9	21.3	22.3	23.1	19.8	17.3	11.8	18.8
5	12.6	21.3	18.7	22.5	22.3	22.8	18.3	17.7	13.0	18.8
6	14.1	15.3	18.3	17.0	19.1	16.4	16.8	15.3	11.0	15.9
7	13.2	14.1	16.2	17.3	18.7	20.0	12.6	14.4	12.8	15.5
8	17.1	18.7	19.6	20.2	19.1	18.9	9.5	16.2	14.7	17.1
Mean	14.9	16.6	16.9	18.0	17.6	18.4	15.8	17.3	14.4	16.4

(Sulphate of ammonia constant at 200 lbs/acre)

In this experiment yields of 12 and 13 tons per acre were obtained on plots which received no fertiliser. From this and from experience at some other sites it appears unnecessary to apply a basal dressing of fertiliser if the soil is clay and if it was previously fertilised for sugar cane. The factor limiting yields is more likely to be either spacing, or drought.

Where a high density population has been obtained it may sometimes be profitable to apply up to 4 cwts per acre of 12 : 12 : 17 : 2 compound fertiliser as a top dressing. The importance of such an application depends on local conditions and on the colour and condition of the crop. It should be avoided in October planted onions if vigorous grow this taking place since the onions obtained will be oversized with thick necks and the tops will not dry down satisfactorily.

Compound fertiliser can be applied with a fertiliser distributor, and no damage will result to the crop if it is granular.

In the experiment there were small responses to phosphorus and potassium but not to nitrogen. It would be wrong to over-generalise from this trial. The most important finding is that onions are relatively insensitive to differences in fertiliser rates ranging from zero to 18 cwts per acre under these conditions.

Irrigation

Examination of the rainfall records (Fig. 1) shows that the onion plant is remarkably drought resistant. The heavy rainfall at the end of January occurred before the bulbs had started to form and was followed by almost continuous drought until April, during which time bulbs of reasonable size were produced. Nevertheless the onion crop is also very responsive to irrigation and the yield obtained from an irrigated crop at Cluffs (10 tons per acre) can be compared with that obtained from unirrigated crops sown at the same time at plantations CDEF (5.0, 7.3, 5. 1 tons per acre).

If onions are sown in December, January or later, irrigation is essential. At Graeme Hall for example, 3.5 acres of onions grown without irrigation from a December 18th sowing, yielded only 1.9 tons per acre, and the bulbs were very small.

Onion growing should be of special interest to those who own land which is marginal for sugar cane for example in St. Lucy and St. Philip. The soils in these areas are recommended for onions and irrigation water is known to be available. The onion crop will probably give a better financial return per inch of water than any other crop commonly grown ; three inches of water in some seasons could produce five extra tons of onions per acre (as above) and an additional profit of $ 700 to $ 800 per acre at current prices. (See Section on costs and returns).

Irrigation should enable growers to produce onions from February, March and April sowings to mature during June, July and August when the price is high. Further experimentation is necessary with successional sowings to study the feasibility of producing onions during these months and if possible these plantings will constitute a very profitable line of business.

Harvesting and marketing

Under the dry conditions of February March and April, the leaves dry back *in situ*, and the bulbs are best left in the ground until ripe so that topping and sacking can be done in one operation in the field. Where grading is necessary this is not possible and the bulbs must be transported to a central packing shed. The most convenient method would be to transport the onions in bulk using pallet boxes or tipping trailers. The onions would then be topped, graded and sacked in the packing shed.

It daily pay rates are used (as at Graeme Hall and Plantations BCDEF) then an efficient method of working must be developed. However, the cost of harvesting was reduced more than three times by paying piece-work rates instead of day time rates and children can help the adult members of the family to increase the family work output and to achieve substantial earnings.

In wet weather the problems of harvesting are greater due to difficulty in obtaining ripe bulbs, and because new leaves grow from the bulbs. The regrowth of leaves in maturing onions was a problem with variety Texas Early Grano where irrigation was used experimentally near harvest time to simulate rainfall. Under wet conditions it is also necessary to lift the onions and dry them off the field, since cutworm damage may result if they are windrowed in the field. It may be necessary to construct special drying facilities if onions are to be harvesting during the wet season. Further work on these problems is necessary.

It was not found necessary to clean the onions when harvested in dry weather, buttin wet weather cleaning may be required. Topping, cleaning and grading are best carried out by machine and if next year's scheduled production is achieved, machinery for this purpose would be a sound investment.

The onions from Graeme Hall were sold to the Barbados Marketing Corporation. The Barbados Marketing Corporation provided the onion nets (50 pound bags) and transport to Bridgetown (together worth 11/2 to 2 cents per pound) and paid a price of 10 cents per pound which was later reduced to 9 cents and 7 cents for two grades respectively. Most of the onions were sold locally but a few hundred bags were exported to the Wirdward Islands.

Storage

At Graeme Hall onions were experimentally windrowed in the field, one group being topped before and the other set after ripening. After 14 days drying in the field these bulbs were firm with golden skins and fifty bags from each group were stacked inside a shed at ambient temperatures of 75°-85° F. and examined periodically for rots. After three weeks substantial losses were apparent in both groups, and on examination a black fungus was found inside the crown of nearly every bulb. This was identified by Dr. Harris as *Aspergillus niger* but it is not yet completely clear whether this is the casual organism, or whether it grows in association with bacteria. It is very unlikely that any control measures can be implemented.

Forty bags of onions were also stored at 60° F. in an air conditioned room. At this temperature rotting was equally evident and much more « sprouting » occurred than at normal temperatures.

Although there has been no experimental work on storage of the red varieties in Barbados, overseas experience indicates that they are less susceptible to storage rots and growers have been urged to plant at least half their acreage in Red Creole or Tropicana in the coming season. There is a danger that the home market will be flooded with poor keeping onions if this recommendation is not respected, and such an eventuality would destroy the confidence of growers.

Costs and returns

The actual per acre costs of production obtained from the 10 acres planted at Graeme Hall agricultural station were as follows :

Costs and returns at graeme hall 1968-1969
(E. C. dollars per acre)

(Irrigated*)

COSTS			
Seed	3 lb per/ac twice = 6 lb @ 12.30/lb.....	76.80	76.80
Land preparation and drilling	20 tractor hours — fuel = 70 c/hr	14.00	
	operator = 85 c/hr	17.00	31.00
Pest control	Chemicals.....	68.90	
	Labour for knapsack spraying 55.3 m/hr @ 60 c	33.10	132.00
Irrigation	Fuel 22.4 gall. diesel @ 67 c.....	15.00	
	Labour 30 m/hr @ 85 c	25.50	40.50
Weed control	Hand weeding — women 386 m/hr @ 52 c ...	201.14	
	— men 35 m/hr @ 60 c	21.00	222.14
Harvesting	Women — 332 m/hr @ 52 c	172.64	
	Men — 93 m/hr @ 60 c	55.68	
	Tractor — 107 hr @ 1.52 with operator.....	16.26	224.58
	Total variable costs per ac.		727.02
RETURNS			
46 tons of onions = 10 300 lbs/ac @ 8.5 c/lb	Total returns per ac....		875.84
	GROSS MARGIN per acre.....		148.82

(*) (Costs of irrigation for acre from total cost on six irrigated acres.)

To the costs listed should be added a proportion of the background fixed costs and the costs of the special equipment necessary to grow the crop. The equipment purchased and its cost was as follows :

	Price
Stanhay seed spacing drill S 766 model.....	1.500.00
« Salo » spike-tooth levellingh arrow.....	1.100.00
Cambridge roller	500.00
Total capital cost	3.350.00

Taking costs per annum on a ten-year basis then :	
Depreciation at 10 %	335.00
Interest on capital at 8 %.....	134.00
Maintenance	10.00
Total annual cost	469.00
Per acre cost	46.90

(10 acres onions)

Thus on the basis of these costs 4.6 tons per acre is the approximate break-even yield at 8.5c per lb. An illustration of the effect of yield on profit is given below using extrapolated data to take account of the extra costs incurred by the higher yield.

Yield	Profit per acre	
(tons/ac)	(8.5 c/lb)	(10 c/lb)
—	—	—
4.6	0	154.16
5.0	56.40	224.64
6.0	198.22	399.82
7.0	339.80	575.00
8.0	481.38	750.18
10.0	764.54	1 100.54
15.0	1.472.00	1 976.44

Small differences in both price and yield thus critically affect the profitability of onion production. There is no profit at 4.6 tons per acre at 8.5 cents a pound, whereas at the same price 10 tons per acre gives a profit of $ 764 per acre. The incentive to obtain high yields and to manage the crop well is therefore important. The effect of management on profitability can be illustrated by reference to the section on pest control where a eight hour delay in spraying resulted in a probable loss of 4 tons of onions per acre, that is $ 481 in one day. By such mismanagement grower with 10 acres would therefore lose a potential profit of approximately $ 5.000 in a single day.

The price is also critical especially for growers who have no irrigation. Yields on sites without irrigation where proper pest control measures were taken were 5 tons per acre at three sites and 7.3 tons at a fourth site. The yield of 5 tons per acre will give a very small profit at 8.5 cents a pound whereas at 10 cents a pound this is increased four times, to a level which in many cases would be slightly better than that obtained from sugar cane. The price is therefore of crucial importance to a grower who is deciding whether to risk planting onions instead of sugar cane.

Finally, profibability depends on the costs of production, and management can reduce those costs a great deal by improving techniques and methods of payment. The greatest saving can be made by paying piece work rates both for weeding and for harvesting. Piece-work rates for harvesting of 30 cents a 50-pound bag were paid at Cluffs and if the same rate had been paid at Graeme Hall the labour cost (excluding weighing, tieing, carting and loading) would have been $ 618.30 instead of approximately $ 2.000. Paying by the day was 3.2 times and 3.0 times more expensive than piece-work at Graeme Hall and plantations BCDEF respectively.

The second major cost was weeding and again piece work rates could be set. It is necessary to achieve a wage rate which substantially benefits both employer and employee, and under circumstances where day-time-paid work is slow or unsupervised this mutual benefit can always be realised. Other important savings in weeding costs can result from good management, for example by very thorough control in the seedling stage when the field does not appear to be in a weedy condition. Further advances in cost reduction may be made in the future by mechanisation of hoeing, or by chemical hoeing with shielded sprayers using Paraquat (e. g. Hudson's method).

The cost of spraying pesticides can be halved by using tractor mounted boom sprayers instead of knapsack sprayers, saving an additional $ 16 per acre. Some savings may be made on chemicals by selecting the cheapest formulations.

Time of planting will also affect costs of production, since a greater number of irrigations are necessary with dry season plantings. Where June, July and August harvesting is obtained the extra cost is likely to be well rewarded since the market price is higher in these months due to the scarcity of onions on the world market.

The following table shows the variation in cost items at different sites and their dependence on circumstances and management.

Comparison of some cost items at different sites
(1968-1969)

Site	Area (acres)	Weeding (labour)	Pest Control		Fertilizer	Harvesting	Irrigation	
			Labour	Chemicals			Fuel	Labour
		(E. C. dollars per acre)						
Graeme Hall ..	10.0	222.14	33.10	68.90	none	224.58	15.00	25.50
Plant. B	.75	343.05	36.00*	100.00	22.67	164.49		
C	.85	36.78	36.00*	34.12	23.50	102.96		
D	.43	80.28	36.00*	105.34	31.62	267.44		
E	.50	66.00	36.00*	160.80	27.20	316.00		
F	.76	86.37	36.00*	95.58	21.97	324.35		
Cluffs	10.0	49.43	19.50	98.19	22.00	137.77	15.00	11.41

* Estimated.

The future

Success or failure of onion growing in Barbados depends on four main factors :

1. The organisation of marketing and the support of CARIFTA Governments in regulating onion imports and protecting the home market.

2. The managerial skill of growers and their willingness to implement the recommendations set out in this report.

3. The organisation of extension work.

4. Research on all-the-year-round production and storage.

The further development of onion growing could save $ 350.000 by import substitution and there is an export market worth approximately two million dollars, with a requirement of only 1.500 acres of land.

The most important technical problems have been sorted out and the future now depends chiefly on co-ordination and co-operation between Government, growers and marketing organisations.

Summary

CARIFTA onion importations are currently worth approximately two million E. C. dollars per annum and research on the problems of local production in Barbados has been undertaken with a view to the development of an industry capable of supplying this market.

Variety, time of planting and small scale commercial trials (1966-1968) preceded larger scale commercial trials of 1968-1969. Hand methods previously used for sowing, thinning and transplanting have now been replaced by direct-seeding techniques using precision seed spacing drills. These drills were used to plant two tenacre plots and eight 1/2 and 1 acre plots on plantations distributed throughout Barbados. Onion production in 1969 to date is approximately 200 tons as against 30 tons in 1968. The mechanical equipment and techniques necessary for satisfactory land preparation are described.

Yields varied from two to 15 tons per acre. Ten acres of onions at Cluffs Plantation yielded 100 tons. On five plantations onion yields were 2.2, 5.0, 5.0, 7.3, and 5.0 tons per acre without irrigation.

The most important problem was pest control. Leaf-eating caterpillars destroyed the early crops at the seedling stage and several pesticides were unexpectedly ineffective. Other major pests were leaf-miners and thrips. An effective spraying programme was eventually developed and its implementation is the prime factor in the success or failure of the onion industry.

Ten weedicides were used at various rates of application but both residual pre-emergence and post-emergence types were ineffective. Hand weeding was the major pre-harvest cost, 120 to 400 man hours being needed per acre.

A systematic non-randomised fertiliser trial with 243 combinations of NPK showed the relative insensitivity of onions to variations from 0 to 16 cwts per acre, on land taken out of sugar cane.

The costs of production at various sites are compared and suggestions are made for cost reductions in future crops. Harvesting was the most expensive operation but it was reduced three fold by piece-work.

The varieties grown did not store well. The remaining problems to be tackled are all-the-ywar-round production and variety selection for storage quality.

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References

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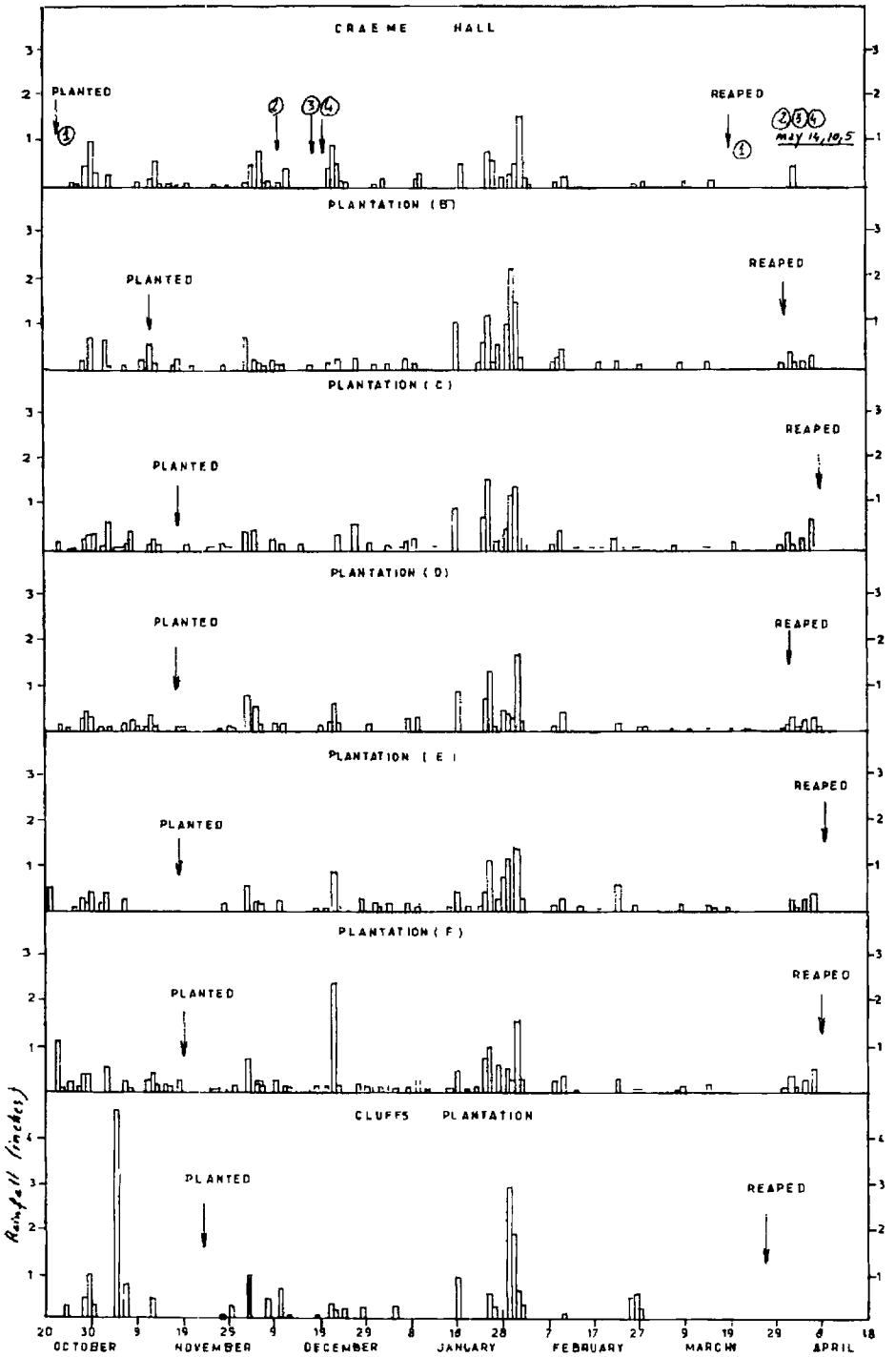

FIG. 1. — Rainfall during growth of onions et seven sites, 1968-69 (inches).