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DIRECT SEEDING OF VEGETABLE CROPS UNDER TROPICAL CONDITIONS IN BARBADOS

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INTRODUCTION

During the last three years in Barbados approximately 1,200 acres of vegetable crops have been direct-seeded by precision seed spacing machines. The number of machines in the island increased from one early in 1969 to 20 in 1972. Through the adoption of this technique an additional 1 1/2 to 2 million E.C. worth of vegetables were produced over the three year period. About 45 farmers have used this method of seeding to produce 523 acres of onions and 300 acres of carrots. A few specialist vegetable producers, notably Farmer Bim Ltd., set up in business and ddirect seeded 100 acres of cabbage and 90 acres of tomatoes and smaller acreages of string beans, cucumbers, melons, beetroot, eggplant, okra, cauliflower, peppers, parsley, radish and squash.

The purpose of direct-seeding vegetables to a final stand is to eliminate hand thinning and transplanting of seedlings. Climatic and soil conditions must be favourable and high management standards are necessary for successful results. The technique cuts costs and increases the acreage of crops which can be handled. The cost of thinning carrots, for example, can amount to over 200 per acre and hand transplanting cabbage and tomatoes 160 E.C. per acre. The greater the plant population density, the greater is the benefit from direct seeding, and with onions and carrots with optimum stands of about 300,000 plants per acre, direct seeding is the only practicable method to use on any scale. With cabbage and tomatoes at populations of about 30,000 plants per acre drilling to a stand is cheaper and the crop matures about 14 days faster, but the method of raising in seedbeds and later transplanting is less vunerable to mismanagement.

SOIL PHYSICAL CONDITIONS AND CLIMATIC FACTORS

For good results the soils should be easily worked to a tilth of high moisture holding capacity, but adequate drainage; sufficiently cohesive to resist erosion during torrential rain, but with enough compressive strength to support frequent passes of tractors and implements; of low penetrability for good root development, but it should not form a surface crust. Largely on account of their high content of coral limestone, Barbados coralline clays are favourable in most of these respects. Although there are problems in workability at extremes of moisture content, at intermediate moisture levels the soils can be cultivated with comparative ease. The clay particles are flocculated into stable aggregates and the excessive swelling and shrinking characteristics of acid poorly-structured tropical clays is not a problem.

There is a transition in the mineral composition of the coralline clays from being predominantly montmorillonitic on the lower terraces to predominantly kaolinitic on the upper more central terraces of the island. The intermediate soils with about equal proportions of the two minerals have the best physical properties. The purer montmorillonitic clays are less well drained whereas the purer kaolinitic clays tend to be overdrained. The intermediate soils, however, are not near a source of water for irrigation and the montmorillonitic soils nearer the coast are, therefore, on account of water availability more suitable for specialist vegetable producers. For various reasons, several of these new specialist farms have been unfortunately sited on poorly drained, deep land over impervious montmorillonitic subsoils. The shallower land in the same area would be more suitable particularly regarding the use of tractors and equipment in the field under wet conditions.

Light, low moisture holding, well drained soils often recommended in textbooks as suitable for vegetable growing in cold climates are not suitable in the tropics. The sandy soils of St. Peter, Barbados for example, quickly dry to below the level of the germinating seed. To maintain moist conditions at seed level and establish the seedlings in the dry season, it is necessary to apply four or five irrigation applications, while on the montmorillonitic clays one or two is adequate. The coralline clays remain moist at seed level for longer periods because their water-holding capacity is much greater per unit volume of soil and because they are 'self mulching', that is a surface layer of dry soil cuts down the rate of evaporation.

The soil's erodibility largely depends on permeability, stability of structure and on slope. Erodibility is important because of the high expectation of torrential storms. Water which cannot pass through the soil must run-off and the damage to young seedling crops is greater on the lighter, sandy and alluvial soils than on the cohesive clays. Carrots are particularly prone since exposure of the taproot after heavy rainfall gives rise to green, deformed roots of poor quality. Slope also influences erosion damage and land chosen for direct-seeding should preferably not exceed 1 in 20 unless the slope is short. The pathways between beds which act as drains should be formed with the slope to prevent storm water flowing across the beds.

Soils which form surface crusts can seriously hinder seedling emergence, onions and carrots being particularly susceptible. The alluvial and flysch soils of St. Andrews, Barbados are bad in this respect. Surface crusts also reduce the percolation of rainfall and on the flysch soil of St. Andrew up to 80 percent of the rain can be lost in this way through increased run-off.

Root penetration into soils also depends on soil physical properties. Long well-formed carrots are formed on soils of easy penetrability and shorter sprangled carrots on resistant soils. The coralline clays at intermediate moisture contents of well prepared to sufficient depth are generally better in this respect than sandy clays or silty soils; in Barbados the sandy clays of St. James and St. Peter are worst.

The cohesive nature of the coralline clays, advantageous in the above respects, presents problems for the engineer in the design of suitable equipment for lifting crops such as carrots and peanuts at harvest. Equipment used in other countries, therefore, has to modified to suit these soils. A further problem is the low compressive strength of the coralline clays, particularly the montmorillonites which when wet limits the use of tractors and equipment in the field.

Only about 1,000 acres could be irrigated in Barbados and, therefore, the feasibility of direct-seeding without irrigation has been examined over the last three years. Satisfactory results were generally obtained when planting between August and December and with slightly more risk between May and August. Within acceptable risk it is possible to produce leafy vegetables without irrigation for the August to January markets and carrots, beetroot and tomatoes through to February, March and April. Onions can be grown without irrigation for December to April markets from September to October plantings and with more risk for August to October markets from May to June plantings. Onions planted from November to March must be irrigated. Most of the vegetables produced from dry season plantings for marketing in the May to August period must also be started with irrigation.

DESCRIPTION OF SEED PLANTING MACHINE

Many types of seed planter are available, the Planet Junior being one which is well-known throughout the world. Recently greater precision in seed spacing has been made possible by the use of either the cell wheel seeder or the belt seeder. The belt seeder handles the widest variety of seed and is the most versatile in seed spacing, therefore, it was the type introduced in 1968 to Barbados. The model in use is the S 766 Stanhay Precision Seed Spacing machine and the basic mechanism is shown in Fig. 1.

Seed flows from a hopper on to a belt perforated with circular holes designed to accommodate seeds of various sizes. The number of holes in the belt and the gear drive from the master land wheels govern the distance between the discharged seeds on the grouhd. A choke controls the flow of seed from the hoppers into the seed chamber and the underside of the belt is supported by a spring base which also helps control seed delivery. If the seeds are small a plain (flat) belt is used over a flat spring base. Plain rubber belts are usually recommended for seeds like cabbage and onion; thinner plain plastic belts are used for thin seeds such as carrots, lettuce and tomato. For larger seeds (e.g. beetroot and string beans) a rubber belt with a projecting rib on the underside is used, the rib running in a grooved spring base.

The hole sizes in the belt are varied in 64th's of an inch, for example No. 10 hole is punched with a 10/64 inch and No. 22 hole with a 22/64 inch punch. Table 1 describes a useful set of belts, spring bases and chokes which have been recommended by the manufacturers for seed from our stocks.

The seeding mechanism is driven from master land wheels by traction on the ground there being four gear ratios permitting four seed spacings for any given belt. A belt with 90 holes worked through pulley gear A, B, C, or D gives seed stations at 1", 1 1/4", 1 1/2", or 2", respectively. The spacing obtained from any gearing is the distance the belt covers on the ground in one revolution divided by the number of holes in it. Because there is a maximum number of holes which can be punched in any belt it is sometimes necessary to fit a triple pulley assembly in the knee joint connecting each metering unit to achieve heavy seed rates (especially useful for string beans).

Distance between rows is controlled by the mounting of the seeder units on to a carrier tool bar. The minimum distance between single rows on a single carrier bar is eight inches. However, a tandem arrangement can be purchased in which an additional set of drills is mounted at intermediate positions on a rear tool bar; the row spacing can then be reduced to four inches. Other adaptations available allow twin or triple rows (1 1/2 to 2" apart) to be planted from each metering unit by fitting special coulter shoes and belts perforated with two or three lines of holes.

In Barbados we generally operate a standard bed width eligned according to tractor track width of 66 inches centre to center. If the tandem drill is fitted with six seeder units in the front and eight inches apart and five units in the intermediate positions in the rear, then it is possible to obtain a wide variety of row widths without further adjustments of the units, as follows:

11 units in use plants 11 rows per bed at 4 inches apart
8 units in use (four in front and four behind) plants 8 rows per bed at 6 inches apart.
6 units in use plants 6 rows per bed at 8 inches apart
5 units in use (rear) plants 5 rows per bed at 8 inches apart
4 units in use (two in front and two behind) plants 4 rows par bed at 12" apart
3 units in use (rear) plants 3 rows per bed 16" apart
2 units in use plants 2 rows at 8, 12, 16, 24, or 32" apart

Each of these units can be operated with single, double or triple row belts so that virtually any row spacing from one inch upwards is possible.

In practice, we have found that double rows are particuarly useful for onion and carrot production, three twin rows substituting for six rows eight inches apart. The population density is the same in both systems and yield is thought to be unaffected. Weed control is easier becuase there are fewer, wider pathways. If germination is poor from three twin rows, then another two twin rows can be drilled in the intermediate positions without the need to sacrifice those plants already established in the first planting.

The cheapest least sophisticated version of the machine is three unit model fitted with single and double coultere and belts. Most crops could be planted with this machine.

INCREASING PRECISION OF SEED SPACING

Natural seeds is variable in size, therefore, to achieve greater accuracy in spacing with the seed planter it is necessary to use either graded or pelleted seed. Seed grades are described by letters of the alphabet each grade being within 1/4 mm. For example seed grade F is 1 1/4 to 1 1/2 mm. while seed grade Y is 5 1/2 to 5 3/4 mm. The number of single seed drops from a given belt will usually be higher from graded seed.

Grading is not too helpful with irregular-shaped seed such as carrot, lettuce and tomato, and better results can be obtained by pelleting. Each seed is coated by cementing material to obtain a spherical shaped pallet. The pellets are uniform in size and can be spaced very accurately. A cheaper oval-shaped minimum-coated or 'mini-pellet' is also produced and is useful for carrot seed in particular.

The usefulness of grading and pelleting depends on the extra cost and whether extra precision in spacing is really worthwhile. Generally in Barbados we find that results with natural seed are good enough and the stand tends to be dominated by field germination percentage rather than by seed spacing.

CALCULATING THE SEED RATE

To calculate the weight of seed needed to plant an acre with any given system of rows, first establish the average row width. For example six rows eight inches apart in beds 66 inches centre to centre would give an average row width of 11 inches. Next look up from tables or calculate the row feet per acre for rows of this width. An average row width of 11 inches for example measures 47,520 ft per acre. To obtain the number of seeds needed per acre multiply row feet per acre by the number of seeds needed per ft. run of row; e.g. 47,520 x 12 = 570,240 seeds per acre. Divide this by the seed count per lb. of seed; e.g. 570,240/105,228 = 5.42 lbs. per acre.

In determining the number of seeds which should be planted per foot of row the field germination percentage must be taken into account. This will be less than the laboratory germination percentage and a figure of 60 percent is often used but should be edjusted according to local conditions and a recent germination test. Then,

$$\text{Seeds per foot of row} = \frac{100 \times \text{Plants required per ft.}}{\text{Estimated field germination}}$$

Table 2 gives some examples of calculations and the seed rates required for local conditions.

LAND PREPARATION

In Barbados direct-seeded crops are often planted after sugar cane, the soil being in good physical condition and relatively weed free. The land is subsoiled and the stumps are thoroughly cut up with disc harrows. Further breakdown of stumps can be done by rotavating or by harrowing carrying out the operations under dry conditions to avoid over consolidation of the soil.

Next the land is marked out using tractor wheel tracks at 66" centers aligning the first bed dead straight with marker poles. If carrots are to be planted then the beds between wheel tracts should be rotavated as deeply as possible taking care to keep to the original wheel tracts throughout the field. This avoids any consolidation in the beds which would affect carrot root growth. It will be found that a 70 inch rotavator is better than a 60" model and that it is necessary to reform the wheel tracks after each strip has been cultivated. Each bed is also rolled with a Cambridge roller prior to planting.

After harvesting a vegetable crop the cultivation method adopted depends on time of year. In the wet season a quick operation is generally necessary because rainy weather limits the number of opportunities for cultivation. The rotavator can be used under quite wet conditions and is the only implement which will destroy the surface trash and prepare a seedbed under Barbados conditions in one operation. In the dry season the rotavator does not give sufficient depth of cultivation if the subsoil is dry and it is necessary to precede it with mouldboard ploughing. The use of rotavators on the coralline clays of Barbados does not adversely affect soil structure as it does on non-cohesive sandy or alluvial soils.

OPERATION OF THE PLANTER

After mounting the seeder units on the carrier tool bar to give the row widths required, the depth of planting is set by setting the coulter shoes below the level of the seeder unit land wheels. For most small-seeded crops a depth of 1" is satisfactory under local conditions, but adjustments may be necessary according to the firmness of the soil. Each metering unit is then prepared with the correct belt, choke and spring base making sure before fitting that the hopper and seed chamber are free from cobwebs and thoroughly clean. After carefully fitting the metering units to the coulters the correct pulley gear is selected, making sure that the same gear is used on either side of the machine. Before drilling starts the stabilizing bars or chains on the tractor are set to locate the machine in the centre of the wheel tracks.

Before placing seed in the hopper it is important to dress it with a mixture of insecticide and fungicide (e.g. Thiram or Captan with BHC or DDT). Use 1 1/2 to 3 oz. per 100 lbs. of large seeds or 6 to 8 ozs. with 100 lbs. of small seeds (i.e. about 1 teaspoonful per lb. of seed). It is important not to use too much seed dressing as surplus powder interferes with the planting by blocking holes in the seed belt and by causing belt slip. The seed should be either dressed in specially constructed rotating drums or by vigorously shaking it in small amounts inside a container. Seed dressings are very important and should not be omitted.

After pouring the seed into the hoppers the master land wheels are rotated in the direction of travel and a check is made at the delivery end of each seeder unit to ensure the seed is being discharged correctly. The machine is then lowered to the ground and a check is made on the master land wheel adjustment to ensure it is making sufficient contact with the ground to turn the seeder mechanism. The tractor operator next selects the correct forward speed, which is usually between 2 and 3 mph. Speeds up to 4 mph are occasionally used with 'D' gear engaged where really accurate spacing is not required. Theoretically spacing is independant of forward speed but in practice if the belt turns too fast the seed does not have time to fall into the holes and if the belt turns too slowly there may be more double or triple drops of seed than desirable.

An electrical monitoring system which warns the tractor operator of any stoppage or jamming of the seed belts can also be fitted. This consists of a panel of light-bulbs connected to the individual seed drills via the tractor battery and mounted in front of the operator. These lights continually flash off and on as the seed belt turns but remain either on or off if a belt jams. The individual seeder giving trouble can then be identified. This system also includes a warning light to indicate that it is necessary to refill the hoppers with seed. If the monitoring system is not in use it is essential that someone follows the seeder to check its performance and after sugar cane when there are many stumps on the ground these must be frequently cleared at the front of the machine to prevent the coulters from lifting out of work.

Under wet conditions soil tends to stick to the rear wheels of the seeder units and periodically has to be scraped off to prevent dragging a groove down the row. Under very wet conditions it is necessary to remove the rear wheels completely and set the master land wheels so that only the front tip of each coulter shoe just touches the ground. The rear of each unit must be tilted upwards away from the soil to prevent soil clogging the exposed part of the belt. Although planting under these circumstances is rather a rough operation it is often necessary during the wet season in Barbados if a succession of crops has to be maintained, and it at least doubles the number of opportunities for seeding as compared with using the planter in the conventional manner.

RESIDUAL WEEDKILLERS APPLIED AFTER PLANTING

Selective residual weedkillers can be usefully applied after planting and before crop emergence to control germinating weed seedlings. After the land has been in vegetables for sometime their use becomes obligatory because of the worsening weed problem.

It is best to apply the weedkillers to a smooth soil surface, therefore, the land should be first rolled. A boom sprayer fitted with fan jets should be adjusted and calibrated to apply about 50 to 60 gallons of spray per acre. Care should be taken that the amount of chemical applied per acre is accurate and that mixing in the tank is thorough.

The residual weedkillers used widely in Barbados are Dacthal W 75 at 10 lbs. per acre for onions, cabbage, and string beans; Gesagard 50 (Prometryne) at 2 lbs. per acre for carrots and okras; Asulox 40 at 4 1/2 pints per acre for tomatoes, melons, cucumbers and peppers. If there are already weeds in the seedbed at the time of spraying then Grammoxone (Paraquat) can be used at the same time.

Several of the residual weedkillers, notably Dacthal, are more effective under wet conditions and in dry weather it is necessary to irrigate after spraying. Too much water, however, can cause leaching and reduce the effectiveness of the chemical.

IRRIGATION

The emerging seedlings are most susceptible to drought at the chitting stage after the root has grown out of the seed coat and before it penetrates into deeper soil. Care should, therefore, be taken in the dry season to apply enough water at this stage. The rate of application of irrigation should not be sufficient to breakdown the structure of the surface soil since crusting hinders seedling emergence. On the coralline clays 0.25 to 0.30 inches per hour is satisfactory.

PEST AND DISEASE CONTROL IN THE EMERGING CROP

The young emerging seedlings are very vunerable to pests and diseases which can ruin efforts to direct-seed to a stand if left uncontrolled. Extreme vigilance at this stage is an essential aspect of the success of this method. Daily inspections are necessary together with rapid action with the appropriate spray treatments.

FAULT FINDING GUIDE

The inexperienced user of direct seeding techniques often fails to identify reasons for disappointing results. The following list may help in systematic checking of possible failures.

Failure may be due to:

1. Poor seedbed preparation (especially over-consolidation of soil). The methods described will help avoid drilling over wheel-tracks.
2. Mistakes in setting up seeder units, e.g. wrong belts, chokes or spring bases; choke badly fitted; spring bases fitted wrong way round; belt fitted with smooth side inwards instead of rough side in.
3. Rust preventing internal rollers from turning causing belt slip. The rollers should be oiled with small amount of light oil after use.
4. Master land wheels not in traction with ground or 'skipping'. Correct adjustment is very important.
5. Use of wrong pulley gear giving incorrect spacing; or use of different pulleys on opposite sides of the machine.
6. Stretch in master land sheel pulley belts, affecting drive.

7. Wrong depth setting on coulter shoes. A check is always necessary to make sure the seed is being covered with soil. On the other hand if planted too deep emergence will be poor especially under wet conditions.
8. Failure to center the machine between tractor wheel tracks by use of stabilizing bars or chains, this causing crooked rows and loss of outside rows behind wheel-tracks.
9. Dirty hoppers (filled with cobwebs etc.) and failure to fit them hopper properly into the coulter.
10. Stumps or rocks blocking the front of the seeder so that the front wheels lift out of position and the seed is not covered.
11. Soil sticking to rear wheels of the seeder units and dragging.
12. Soil blocking the delivery part of the seed belt. To avoid this the tractor should always be moving forward as the machine is lowered to the ground.
13. Operating at too fast a speed (use recommended speeds).
14. Use of too much seed dressing causing blockage of holes in the belt and belt slip.
15. Failure to use any seed dressing (or failure to use two components in the seed dressing- a insecticide and a fungicide.
16. Too much or too little irrigation.
17. Failure to identify and control pests during seedling stage.

When introducing precision seed planters on farms it is essential to train operators thoroughly in their proper use. For this reason emphasis has been placed in this paper on practical details since careful operation of the machine is a foremost factor in the successful use of direct-seeding.

SUMMARY

Over 1,200 acres of vegetables have now been direct-seeded by precision seed spacing machines in Barbados, the technique eliminating hand thinning and transplanting. Greatest benefits are obtained with onions and carrots with high population densities but savings in cost are also made with cabbage and tomato and most vegetables. Soils should be easily worked to a tilth, moisture retentive, cohesive and erosion-resistant. Good results have been obtained between July and December in direct-seeding without irrigation but irrigation is essential in the dry season. The seed spacing machine, its operation and the grading and pelleting of seed are discussed. Calculations for different row spacings on beds for amount of seed per acre, and practical aspects of land preparation, planting, weed, pest and disease control and irrigation are described and a fault-finding guide to assist in identification of problems is presented.

Table 1. List of seed belts, spring bases and chokes recommended for Stanhay S 766 seeder for spacing vegetable seeds used in Barbados.

Seed	Recommended belt hole size x no. of holes	Spring base	Choke	Spacing (inches) per station	Tractor speed mph	Pulley (4 gear model)	Unit rpm	Average no. of seeds per station
BEANS (String)								
Bountiful	Ribbed II 34 x 32	T2	P	2.8"	2mph	A	60	
Tendercrop or Gallatin 50	Ribbed II 36 x 32	U2	P	2.8"	2mph	A	60	1.17 1.15
Topcrop or The Prince	Ribbed II 42 x 28	U2	P	3.2"	2mph	A	60	1.28 1.27
Contender	Ribbed II 49 x 24	L2	None	3.75"	2mph	A	60	1.35
BEETROOT								
Detroit Dark Red	Ribbed II 16 x 36	C2	X	2.5"	2mph	A	60	
Early Wonder	Ribbed II 13 x 36	S2	X	2.5"	2mph	A	60	1.07
Redpack	Ribbed II 19 x 36	D2	X	2.5"	2mph	A	60	1.04
CABBAGE								
Emerald Cross	Plain II 9.5 x 28	A2	T	3.2" or 4.0" or 4.8" or 6.4"	2mph 2.5mph 3.0mph 3.3mph	A B C D	60 60 60 50	1.03
CO Cross	Plain II 8.5 x 28	A2	T		ditto			1.08
CARROT								
F1 Gold	Green Plastic 9.5 x 72	A2	C	1.9"	3.0mph	C	60	2.19
F1 Early Cross	Green Plastic 9 x 72	A2	C	1.9"	3.0mph	C	60	1.90
CARROT								
Chantenay Red Cored No5	Green Plastic 10 x 72	A2	C	1.9"	3.0mph	C	60	2.05
CAULIFLOWER								
Early Patna	Plain II 8 x 28	A2	T	Same as cabbage				
COW PEA								
Floricream	Ribbed II 26 x 30	D2	P	4.5"	3.0mph	C	60	1.00
CUCUMBER								
Poinsett or Gemini Hybrid or	Plain II 28 x 15	A2	A	12"	2.6mph	D	40	1.57 1.80
Challenger Hybrid and Saticoy Hybrid or	29 x 15			ditto				1.92
Triumph Hybrid	28 x 15							1.82

Table 1 continued

Seed	Recommended belt hole size no. of holes	Spring base	Choke	Spacing (inches) between stations	Tractor speed mph	Pulley (4 gear model)	Unit rpm	Average no. of seeds per station
EGGPLANT								
Black Beauty	Green Plastic 11 x 45	A2	T	3.0"	2 mph	C	40	
LETTUCE								
Mignonette Bronze	Green Plastic 10 x 72	A2	C	1.9" or 2.5"	3.0mph 2.7mph		60 40	
Empire	Green Plastic 9.5 x 72	A2	C		ditto			1.18
CANTALOUPE MELON								
PMR 45	Plain II 28 x 15	A2	A	12"	2.7mph	C	40	1.93
Dulce	Ribbed II 30 x 15	B2	A	12"	2.7mph	D	40	1.5 approx
Perlita	Plain II 29 x 15	A2	A	12"	2.7mph	D	40	1.81
OKRA								
Clemson's Spineless	Ribbed II 19 x 45	D2	X	3.0"	3mph	C	60	
ONION								
Granex F1 Hybrid	Plain II 10 x 90	A2 or F2	T T	1.0" 1.0"	2mph 2mph	A A	60 60	1.09 1.45
	Plain II 11 x 90	A2	T	1.0"	2mph	A	60	1.11 (different sample)
	(seed size varies slightly from sample to sample-- it is safer to use the larger hole (No. 11) or F2 base with No. 10 hole.							
Dessex	Plain II 10 x 90	A2 or F2	T T	1.0" 1.0"	2mph 2mph	A A	60 60	1.25 1.26 (different samples)
R 10 Hybrid	Plain II 10 x 90	A2 or F2	T T	1.0" 1.0"	2mph 2mph	A A	60 60	1.26 1.76 (tests on same sample)
Red Creole or San Joaquin	Plain II 9.5 x 72	A2	T	1.25"	2mph	A	60	1.30 1.31
PARSLEY								
Moss Curled	Green Plastic 9 x 90	A2	C	1.0"	2mph	A	60	1.98
PEANUT								
Tennessee Red	Ribbed II 40 x 18	V2	None	5.0"	2mph	A	60	1.20
Barbados variety - Virginia Bunch	A ribbed belt with No. 49 hole and V2 base can be used but seed is rather too large for this type of machine.							
PEPPER								
Yolo Wonder	Green Plastic 13 x 72	A2	T	1.8"	2mph	C	40	
PIGEON PEA								
Dwarf type from Trinidad	Ribbed II 24 x 28	D2	P	4.0"	2.5mph	B	60	1.00
SQUASH								
Zucchini	Ribbed II 49 x 15	D2	P	12"	2.7mph	D	40	

Table 1 continued

Seed	Recommended belt Hole size No. of holes	Spring base	Choke	Spacing (inches) between stations	Tractor speed	Pulley (4 gear model)	Unit rpm	Average no. of seeds per station
RADISH								
Scarlet Globe	Plain II 11 x 90 (double row)	A2	T	0.50"	2mph	A	60	
TOMATO								
Bounty	Green Plastic 12 x 24	A2	T	5.9"	2mph	C	40	
Walter								2.06
Tropi Red								2.19
TURNIP	Plain II 7 x 72	A2	T	1.9"	3mph	C	60	
SOYA BEAN	Ribbed II 26 x 24	D2	X	5.9"	3mph	C	60	
SORGHUM	Ribbed II 16 x 45	G2	X	3.0"	3mph	C	60	
WATERMELON								
Sugar Baby	Plain II 32 x 15	A2	A	12"	2.7mph	D	40	1.38
					3.3mph		50	1.17
					4.0mph		60	1.13

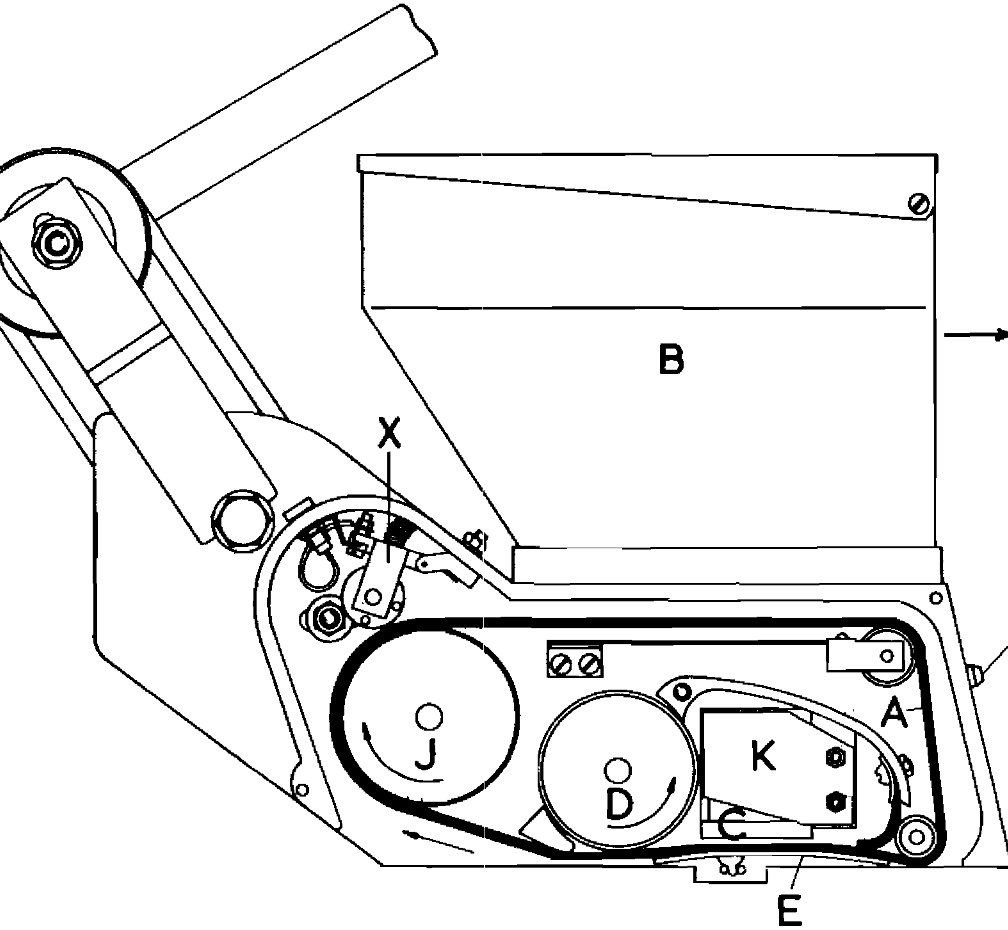
Notes:

1. For twin rows or triple rows belts should bo punched with two or three lines of holes and used with double and triple coulter shoes respectively.
2. The manufacturers can test seed samples or make recommendations for graded and pelleted seed.

Table 2: Number of seeds per lb and weight of seed per acre for different crops planted on beds between wheel tracks 66" centre to centre.

Crop and variety	no. of rows per bed	Average row width	Row length per acre (feet)	Seed stations per ft	No. of seeds per ft	No. of seeds per lb	Lbs of seed /acre
Beans (string) Toporop	4 singles rows 12" apart	16.5"	31680	3.75	4.80	1,089	140
Beetroot Early Wonder	5 single rows 8" apart	13.2"	39600	4.80	5.13	20,430	10
Cabbage Emerald Cross	3 single rows 16" apart	22.0"	23760	3.0 3.75	3.09 3.86	104,420	0.70 0.89
Carrot F1 Gold	6 single rows 8" apart or 3 twin rows, 16" apart	11.0"	47520	6.32	13.84	296,916	2.2
Cucumber Gemini Hybrid	2 rows per bed 16" apart	33.0"	15840	1.0	1.80	16,344	1.7
Cantaloupe Perlita	2 rows per bed 16" apart	33.0"	15840	1.0	1.93	21,792	1.4
Eggplant Black Beauty	2 rows per bed 16" apart	33.0"	15840	4.0	8.00	105,782	1.2
Lettuce Empire	3 rows per bed 16" apart	22.0"	23760	4.8	5.66	439,084	0.3
Okra Clemson's Spineless	3 rows per bed 16" apart	22.0"	23760	4.0	4.0	8,172	11.6
Onion Granex F1	6 rows per bed 8" apart or as twin rows	11.0"	47520	12.0	13.08	114,408	6.2
Onion Dessex	ditto	11.0"	47520	12	15.00	105,228	6.7
Onion R 10 Hybrid	ditto	11.0"	47520	12	15.12	134,930	5.3
Tomato Walter	3 rows per bed 16" apart	22.0"	23760	2.03	4.18	161,482	0.6
Watermelon Sugar Baby	1 row per bed	66.0"	7920	1.00	1.38	10,896	1.0

(for details of estimate of seeds per foot see Table 1)



SD/559/2-S870 METERING UNIT & KNEE JOINT

Legend to Figure 1

A - Seed belt...
B - Seed hopper
C - Seed inlet port
D - Repeller wheel
E - Spring base
F - Knob to locate metering unit in chassis.
J - Drive wheel
K - Choke controlling size of inlet port
X - Electrical monitoring sensor