DESIGN DEVELOPMENT AND TESTING OF BULLOCK DRAWN COTTON PLANTER

THESIS

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DECLARATION OF STUDENT

I hereby declare that the experimental work and its interpretation of the thesis entitled "DESIGN, DEVELOPMENT AND TESTING OF BULLOCK DRAWN COTTON PLANTER" or part thereof has not been submitted for any other degree or diploma of any University, nor the data has been derived from any thesis/publication of any University or Scientific Organisation. The source of materials used and all assistance during the course of investigation have been duly acknowledged.

AKOLA
DATED- 12/8/88

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CERTIFICATE

This is to certify that the thesis entitled "Design, Development and Testing of bullock drawn cotton planter" submitted in partial fulfilment of the requirements for the degree of Master of Technology in Agricultural Engineering(Farm Power and Machinery) of the Punjabrao Krishi Vidyapeeth, Akola, is a record of bonafide research work carried out by Shri Sahebrao Mahadeorao Bhende under my guidance and supervision. The subject of thesis has been approved by the Student's Advisory Committee.

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LIST OF ABBREVIATIONS

Agril.	Agricultural
AMA	Agricultural Mechanization in Asia Africa and Latin America
A.S.A.E.	American Society of Agricultural Engineers
C.I.	Cast Iron
Cm	Centimeter
d.b.	Dry basis
dia.	Diameter
Engg.	Engineering
F.P.I.	Field Performance Index
F.P.M.	Foot Per Minute
gm.	Gram
ha	hectare
hr	hour
H.P.	Horse Power
I.C.A.R.	Indian Council of Agricultural Research
J.	Journal
Kg.	Kilogram
m	Meter
M/c	Machine
Min.	Minute
mm	Millimeter
M.S.	Mild Steel
P.K.V.	Punjabrao Krishi Vidyapeeth
r.p.m.	Revolutions per minute
Sec.	Seconds
Trans.	Transaction.

CHAPTER I

INTRODUCTION

Cotton is a cash crop of India and plays an important role in national economy. India ranks first hectarage under cotton in the world but stands fourth in production. In India cotton is grown over the area of about 7.765 million hectare with production of about 6.585 million bales annually. Maharashtra is the largest cotton growing State in the country with an area of about 2.753 million hectare with production of about 1.175 million bales. In Vidarbha, area under cotton is about 1.79 million hectare producing 0.495 million bales.

Economy of Vidarbha farmers mainly depends upon the production level of the cotton. Amongst the various factors of the production, plant population per unit area is an important one. There are two categories of cotton crop namely,Gossipium Hirsutum(American) and Gossipium arborium(Deshi) which are sown in Vidarbha. For these, American and Deshi cotton, there are various high yielding hybrid varieties adopted by the farmers.

According to the various varieties,different optimum plant spacings are to be maintained to maximise the production. Most common, plant spacings are from 30cmX15cm to 120cmX120cm for different varieties of both Deshi and American cotton in different type of soil. In Vidarbha, cotton crop is sown manually which consumes more time and money. Inspite of this the crop is to be sown within the stipulated time period.

For American cotton varieties, most of the farmers have adopted the check row planting methods. These check rows are marked with the help of marker operating from two directions i.e. crosswise. After sufficient rain has occured, sowing is done on each cross marking or cross hill manually by means of labour. The sowing of crop is the placement of seed in the soil at the proper depth, with proper moisture and the soil temperature. The seed sown should be in proper quantity to achieve the desired plant population. Precision and timeliness are important aspects of modern agriculture.

Sowing is done manually at each cross, three or four seeds are sown. If moisture zone is not available, then the germination is not successful. Thus sowing at proper depth of moisture zone in the soil is important factor for successful sowing of cotton which cannot be achieved manually.

During the peak periods, particularly during sowing season, the labour supply fall short. Skilled labour for sowing is not available which cause delay in sowing of cotton. This ultimately hampers the yield of cotton. The experiments have shown that delaying sowing by one day results in reduction of yield of cotton to the extent of 20 kg per acre.

Thus timeliness precision can be achieved only if mechanical device is introduced in sowing of cotton versality of implement widens the scope of improved implement. Thus sowing unit which could cover larger crops varying soils and seed rates per hectare is most acceptable.

Moreover it should be easy in operation and adjustment. It should be rigid and maintained any adjustment throughout the operation without break-down or any other disturbances.

Considering all the above points, it was felt imperative to tackle the problems of planting of cotton crop in Vidarbha. An attempt, therefore, has been made to design and develop the cotton planter with a view to incorporate as many of the desirable features as possible. In designing the cotton planter, the field experience research results of previous workers have been considered.

The proposed cotton planter is expected to perform the following functions:

1. To place cotton seed(Deshi)uniformly in lines at a required distance.
2. To adjust spacing within and between the rows as well as for adjustment of depth of sowing.
3. To sow three to four seeds of American cotton in each hill at a required hill spacing.
4. To adjust plant spacing within the hill and between the row from 45cmX45cm to 120cmX120cm.
5. Covering the seed after they are dropped in the furrows.
6. To disengage the seeding mechanism whenever required so that seeds would not drop even when the ground wheels are in motion.

7. The feeding unit should not damage the seed.
8. It should also able to sow the intercrop like mung, udid etc. in between the cotton.

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CHAPTER II

REVIEW OF LITERATURE

The indigenous seed-drill used for sowing in many parts of India has remained basically unchanged in its design uptill now. However, the seed drills for sowing the grains in rows designed fabricated in India, fulfil the maximum conditions and gives good performance. The research and development for precise planting machine for a particular crop like cotton is very less in India because it requires some complicated mechanism for satisfying the conditions required for planting, hence limited literature is available in India. In United States of America and other Western countries, the progress of farm mechanization started in the middle of the century and as such fully mechanised sowing and fertilizer placement device have almost reached to a perfection. Planting equipment consist of different parts or units to fulfil the different requirement. The following paragraphs indicate the review work of past workers on various aspects and designs on planters in India and abroad.

The review work is catagorised as follows:

1. Agrotechnical requirements
2. Precision planters and metering devices
3. Hill drop mechanism
4. Furrow openers
5. Seed tubes
6. Testing

2.1 Agrotechnical Requirements

2.1.1 Seed Characteristics

Kanwade and Kashyap(1981)

Seed dimension, thousand seeds weight, true density, bulk density and angle of repose of cotton seed of J-34, L.S.S.(American)and G-27(Deshi) varieties were studied with respect to delinting methods. ~~Acid~~ delinted cotton seed were most convenient for handling, processing and planting as they had good flow characteristics. In their study they have derived some physical characterstics of the cotton seed(Table-2.1).

2.1.2 Seed Emergence

Staut *et al.*(1960)

Laboratory experiments were conducted to determine the effect of compaction on emergence of seedlings from sandy clay loam at various moisture contents. Field conditions were simulated by placing on 20 cm layer of undistributed sub-soil in a box and covering it with an 20 cm layer of tilled top soil. Water was added to each box at the bottom 40 cm below the surface. Heat lamps were placed above the soil surface and a 8 Kmph wind was simulated by drawing across the soil surface. The air temperature was maintained at 60^{o}F. Emergence of sugarbeet bean and corn seedlings was observed after the soil was compacted at the surface or at the seed level.

Under the condition employed in this laboratory study, pressure in excess of 0.035 kg/cm^2 was applied at

Table 2.1: Some physical characteristics of undelinted and delinted cotton seed.

Variety	Treatment	True density g/ml	Axial dimensions in mm			Porocity percent	Thousand seed weight(g)	Percent fuzz by weight
			a	b	c			
J-34	Undelinted	0.909	9.59	5.62	5.13	70.30	65.30	7.38
	Mechanically delinted	0.909	9.27	5.12	4.54	57.54	63.46	4.56
	Acid delinted	0.952	7.16	4.12	3.76	41.18	60.48	0.00
L.S.S.	Undelinted	0.952	9.21	5.49	5.05	69.64	69.91	6.95
	Mechanically delinted	0.952	8.18	4.67	4.12	53.63	67.88	4.04
	Acid delinted	1.000	6.93	3.92	3.76	43.00	65.06	0.00
G-27	Undelinted	0.952	7.22	4.51	4.28	63.45	45.23	4.99
	Acid delinted	1.000	6.50	3.64	3.52	41.20	42.98	0.00

a= Major axis, b= Minor axis, C= Axis perpendicular to 'a' and 'b' the surface usually suppressed emergence of seedling. Pressure of 0.35 to 0.70 kg/cm^2 was applied at seed level. These results indicate that planter should be designed to apply the higher pressure to the soil at seed level but should place relatively loose soil above the seed.

2.1.3 Plant spacing

According to the P.K.V.Diary(1988), the plant spacing for different varieties of cotton and for different soil types are shown in Table 2.2.

Table 2.2

Recommended plant spacing of cotton for Vidarbha region.

Type of cotton	Spacing	Plant population per hectare
Deshi cotton	45 x 22.5 cm	100000
	60 x 15 cm	111000
	60 x 30 cm	56000
American cotton	90 x 60 cm	18000
	90 x 90 cm	12000
	120 x 90 cm	9000

Daterao(1976) stated that planting one plant per hill resulted in increased dry matter weight per plant, more number of harvested bolls and higher seed cotton yield per plant. However, in respect of seed cotton yield per hactore, two plants per hill was outstanding superior to single plant per hill.

Crop quality was not improved either by keeping one plant or two plants per hill.

2.1.4 Depth

Batchelder, Galen and Laughtim(1979).

Two planting devices used with and without depth control bands and three row spacing were evaluated for dryland and cotton production over a three year period. Highest emergence was obtained for a precision planter, the use of depth bands, of a 25.4 cm row spacing. Highest yields were associated with the precision planter, the use of depth bands for cotton planted in the 25.4 cm and the 1.02 m row spacing.

2.2 Different Precision Planter and Metering Devices

Bainer(1947) observed in testing the uniform metering metering of seeds, it is essential that the cells in the planter feed the seed to be planted. The diameter of the cell should be 0.4 mm larger than the maximum diameter of the seed to ensure proper clearance. Movement of the seed though seed cell is further improved by tapering the cell wall from top to bottom. Tapering to an inclined angle of approximately 12 dig. is sufficient to ensure free movement of the seed through the cell. Proper plate thickness depends upon the type of seed.

Arthur(1947) stated that the increase in plate speed always decreases the percent of cell fill and, therefore, also the planting rate. If seeds are large in relation to the seed cells, there is a great variation in planting rates resulting from change in speed.

Futral and Allen(1951) studied on development of a high speed planter and investigate some reasons for the drop in planting efficiency at higher speed.

1. The plates of the inclined cell plate type were rotating so fast that seeds were frequently carried past the drop out opening.

2. The inertia of the spring loaded kick out mechanism used on the flat plate type planter was too high to function properly and damage resulted to the seed when spring tension was increases. Therefore, a belt type planter was developed. A belt perforated by properly sized holes runs at a 45 deg. angle through the hopper. Seeds fall into the holes and are carried up and out of the hopper. Near the top of the belt path a soft rubber retaining but contact the seed belt and presses against it during the vertical descent, thereby holding the seed in place until the belt seperate at the bottom. The action of the seed belt in changing from a vertical to a horizontal positions imparts to the seed a positive downward velocity resulting in their being thrown to the ground.

Bainer <u>et</u> <u>al</u>.(1960) have mentioned that horizontal plate planters have spring loaded cut off devices that ride on the top of the plate and "wipe" out excess seeds as the cells move beneath them. Spring loaded knockout devices push the seeds from the cells when they are over the seed tube or boat.

Brandt and Fabian(1964) reported that the horizontal rotating seed plate in hopper bottom has been established to be the most economical and dependable metering de ice. They further found that if the seed cell did not fill within the first five centimeters of exposure beyond the cut-off cup, it seldom got filled throughout the remaining exposure. Increasing the number of cells per plate beyond 16 and reducing the R.P.M. did not increases cell fill accuracy in proportion to the increase in number of cells.

Elmer Hudspeth and Wanjura(1970).

The use of vacuum for metering single cotton seed has not been fully evaluated with the benefit of previous research and experience a vacuum wheel to meter single chemically delinted cotton seed was constructed. In this, the vacuum part was located on the front side and not the end of the spoke. This gave the wheel a mechanically assisted pick-up. A seed hopper was attached in a position that exposed the wheel to the seed supply for about 90 deg of its rotation. Each suction part picked up seed while passing through the seed box, retaining it until the bottom centre point of its retention was approached. The vacuum was broken at the bottom centre point and the seed was released.

Metering comporison were made between the vacuum wheel and a conventional grain double run, while planting the cotton seed. The seed had a germination of 90 per cent. Seed spacing of 10 cm and 20 cm were used for the vacuum wheel and a metering rate equal to 10 cm spacing was planted with the double run metering wheel.

The metering was superior of vacuum wheel. Wheel speed from 20 to 50 rpm. of the vacuums of 2.5 cm to 12.5 cm of which had only minor influences on the performance of the spoked vacuum wheel. Other sets showed that the mechanism assisted vacuum pick-up was superior than a system using only suction.

Jafari and Fornstrom(1972) studied on a precision punch planter for sugar-beet. The objectives of this study were to design a sugar-beet planter which would maintain uniform seed, spacing and depth, plant single seed without any seed damage, plant resonable planting speeds, and provide a seed environment which might promote emergence.

A wheel having cones on its periphery was used to establish conical identation in the row for each individual seed. The seed metering system employed a vertical rotating disc to drop single seed into the ground holes. The system was independent of speed, as it gaves seed zero relative velocity with respect to the ground.

As a result of laboratory and field test it was concluded that the planter met the design objectives. The planter was simple in design and operation would greatly improve uniformity of seed placement and speed of sugar-beet planter.

According to Bernacki _et al_.(1972), control of seeding rate by means of studed rolls is possible only by changing their peripheral speeds, i.e. by maintaining a constant size of the opening in the hopper. This favours keeping the seed stream sufficiently uniform even if the seeding rate per hectare is low. Moreover, the frequency of immediate influence of studed roll on seed layer in the slot is higher than that of fluted roll. Also the damages to seeds are very slight(i.e. from 0 - 0.1%).

According to Kepner et al.(1978) the cell diameter or length should be about 10 per cent greater than the maximum seed dimensions and the cell depth should be about equal to the average seed diameter or thickness. Performance would be improve by graded seed within close size tolerance. Cell size was less critical with pneumatic metering devices and was not a factor with vacuum pick-up device.

They also stated that the most seed damage in horizontal plate or vertical rotor metering units was caused by the cut-off device. The percentage of damaged seed increases as the cell speed is increased. Damage is also greater if the cells are too large.

Wilkins, Adrian and Conley(1979).

A two row punch planter was designed, developed and tested with lettuce seed. The planter had a notched seed wheel that rotates in a vertical plane to individually meter coated vegetable seed. Seeds were transferred by magnetic punches. The seed coating contains an iron oxide(Fe_3O_4) which makes them attractive to magnets. The punches firmly imbed the seeds into the soil and ideally, the holes remain uncovered. The test showed that the punch planting system resulted in a shorter time between planting and emergence them when a conventional planter was used.

Wilkins and Lenker(1981). A micro-processor controlled planter was designed for metering raw lettuce seeds. The planter consisted of a syntrom feeder for seed delivery, light emitting diod and photo transistor for seed detection, magnetic pick-up for planter displacement, air stream for seed seperation and a microprocessor to control the timing of seed seperation. Laboratory test on a greased belt indicated that the micro processor controlled planter metered raw letthee seeds with fever errors than a John deere vegetable planter, metered either raw or coated lettuee seeds.

Surendra Singh, Matzen and Pedersen(1983).

The effectiveness of two commercial seeding machine was studied with spring wheat and oats in the field on a sandy loam soil. From the result achieved, it appears that the use of a seeding machine with peg type nylon seed metering device gave better seed emergence and grain yield than that of a machine having helical flutted type nylon seed metering device. There was no significant difference in the dry matter accumulation per unit area in wheat and oat plots for both the drills. This was mainly because of high growth rate may be due to more row to row spacing and less seed emergence as compaired to the plots sown by the machine having peg type seed wheels.

Adekoya and Buchele(1987). A rolling punch planter with a camacuated opening mechanism was developed to plant maize(and other similarly size grain)in tilled and untilled soils. Field tests showed that satisfactory planting of the seed was achieved in an untilled field with upto 75 per cent residue cover(at about 5500 kg/ha). The within the row spacing of the punched holes and the depth of planting of the seeds were independent of the travel speed. The percentage of the punched holes containing a single seed decreased as the travelspeed increased.

2.3 Hill Drop Mechanism

Miller(1949) studied the rotary valve which was 15 cm in diameter and contained 8 cells. Since it was only necessary for the valve to revolve once in an approximately 3 metre while placing 8 hills of seed in furrow, the seed feel more evenly distributed from the seed tube into each cell with a minimum of bouncing about.

The lip and flaper type valve was not hold up to the fast reciprocating movement necessary at high speeds and was not accurately seperate the seed. The hill drop plates was so far from the furrow where the seeds are placed that during the fall through the seed tube and furrow opener. It was tend to scatter so that they were more nearly drilled thin than hill dropped. A remedy for this would to place the hopper immediately above the furrow openers.

Artry and Schroeder(1953) in test with hill drop plates in a conventional horizontal plate panter, without boot valves, found that dispersion occurs as(a)as seed leave the cell,(b)seed fall through the throat and the seed tubes and(c) seed strikes the furrows. The results of these investigations are summarised as follows:

1. Highest accuracy can be obtained by using compact type of cells i.e. short and broad rather than long and narrow.
2. Slow plate speeds(below 9m/min)results in higher accuracy and higher cell fill.
3. Accuracy is affected less by changes in the number of cells per plate, than the speed changes, consequently rates should be varied whenever possible by plate changes rather than plate speed changes.
4. There is a little effect of number of cells per plate on dispersion within the range from 4 to 16. This characteristics permits the use of more cells to obtain a closer spacing without affecting dispersion.
5. A trajectory type of seed tubes conveys the seed more nearly through their normal path and greatly improves dispersion for all seed plates and speeds.
6. Ground scattering is decidedly affected by height of the fall, but it may be reduced by partial restriction of the furrow and by the height of a hopper 45 cm or less.
7. By selecting the proper ratio of ground speed to the plate speed(about 8:2), the effect of the ground speed on dispersion can be kept to a minimum.

According to Kepner and et al.(1978) the valve mechanism was originally developed for check row corn planting but can also be used for random hill dropping. Rotary valves, however was more suitable for high speed operation. In a reciprocating valve arrangement, a cam on the feed shaft opens the two valves simultaneously for each hill. Seeds that had momentarily resting on the lower valve are ejected down and rearward a relatively short distance into the furrow, while seeds accumulated on the upper valve are released to fall down on to the lower valve. Spring action closes both valves.

2.4 Furrow Openers

Reachy et al.(1961) explained the functions of shoe type furrow openers, such as wedge shaped blade opens the soil enough for the boot at the rear to deposit the seed. The sharp blade cuts through clods and sodes. It open the soil enough for receiving the seed with a minimum of disturbances and draft. The notch or slag just behind the bottom portion of the sword allow the moist soil to cover the seed before the dry upper soil closes over it.

According to Bernacki et al.(1972) the shoe opener and a hoe opener each of the types of furrow openers maintains an approximately constant feed depth required and ensure that seeds are fully covered by a scarified layer of earth at various individual sowing depth required. The draft of shoe openers varies from 2-6 kg at h = 2-6 cm, whereas in hoe openers resistance amounts to 3-3.5 kg. The resistance of disk openers in operation varies; subject to the type of soil within limits of 5-12 kg.

According to Kepner et al.(1978), the optimum depth of planting varies widely with different crops and is influenced by soil moisture condition, soil temperature, aeration etc. Some seeds are rather sensative to environmental conditions and require careful control of the planting depth.

The full runner is a simple device that works well at medium depths in mellow soil, free of trash and weeds. It is suitable for the average conditions encountered by corn and cotton planter.

Hoe type openers when equipped with spring trips are suitable for stony or root infested soils.

Disk type openers are suitable for trashy or relatively hard ground. In wet, sticky soils they are more satisfactory than fixed openers because they can be kept resonably clean with scapers.

Morrison and Gerik(1985).

Planter depth control with four wheel design was evaluated on the basis of predicted effect on simulated emergence for four crops. A linked front and rear depth control wheel designed performed similar to rear and front depth control. Side wheel produced the best performance but they are too wide for solid seeded planting narrow rows in crop residues. Depth control wheel position varied the simulated emergence as much as 35 per cent.

2.5 Seed Tubes

According to Bernacki et al.(1972), the size of spreading of freely falling seed depends on height of dropping and is increasing with increase in that height. It is, therefore, clear that a free fall of seeds may be ensured by tubes which widen down their length. In tubes so designed, the greater part of the seed(60-80%) drop down freely without coming into contact with the walls. The other prerequisite is that walls of tubes should be smooth.

Excessive deviation of the tube from the vertical, or their possible deflection, adds to the irregularity of falling seed qualities to opener in a unit of time. In such an instance, a considerable portion of seed strikes against the walls of the seed tubes in falling down and rebounds in various directions at various speeds.

2.6 Testing

Hung(1960) explained that "the planter may be ckecked for performance in the laboratory by powing the drive wheel of the positioned lever. The seed is then caught and examined. A testing for grouping of seeds in a hill may be accomplished by running the planter over a grease board. The seeds are trapped in grease at the point when they just drop".

According to Kepner et al.(1978). Although a ultimate criterion for evaluating a complete planting operation is the stand obtained in the field, these results are influenced by seed viability and environmental factors beyond the control of planting machine. The effect of different types of furrow openers or press wheels can only be determined by field emergence trials, but the performance of a seed metering device can be checked more readily and more reliably in the laboratory than in the field. The resulting seed pattern on a grease board, is representative of the performance of metering device with a seed tubes, but does not show the effect of bouncing in the furrow. Photo sensitive device and electronic units have also been used to record the paths or frequencies of falling seeds.

Nave and Paulson(1979). Five commercial planter meters were compared. A flutted roller meter, an air disk meter, a single run feed cub meter, an air drum meter and a horizontal plate planter. Seed quality comparison were made based on germination test, percentage of splits and percentage of seed coat cracks of the soybean seed.

Seed damage evaluation was carried out by taking the soybean samples collected from each planter meter, samples taken from the free fall drop and the control samples were evaluated by means of germination tests, tetrazolium tests, test for percentage of seed coat cracks. For the seed spacing test, soybean seed were collected from a sand track 14 m long and 0.5 m wide that had a layer of fine white sand about 5 cm. deep. Each of the five planter was pulled over the sand track at 8.8 km/hr. The distance between individual soybeans was recorded for a 3 m section for each treatment. Seed spacing was set to provide about the same population for each planter.

Sadachari Singh Tomar(1983). Studies on performance index of sowing machinery and stated that, to express the relative performance of various sowing machines, a general formula has been evolved by which relative performance index of similar machinery tested under identical conditions with respect to energy used; quality and quantity of work can be calculated. Main factors which affects the performance of sowing in the laboratory as well as in the actual field conditions have been taken into account. He has given the general performance requirements of the sowing machines as follows which are desirable as per the IS-7926-1975 and IS 6813-1973.

i) The inter-opener variation in seed and fertilizer should not be more than 7 per cent and 12.5 per cent respectively.

ii) The variation of actual seed and fertilizer discharge rate should not be more than 7 per cent and 12. 5 per cent respectively with desired discharge rate.

iii) The visible damage after calibration should not be more than 0.5 per cent.

iv) The variation of discharge rate due to different hopper capacity(three fourth, half and one fourth) should not exceed 10 per cent.

v) The variation in quantity of seed discharge should not be more than 15 per cent due to change in speed.

vi) The variation in quantity of seed discharge per meter of row length should not be more than 10 per cent.

vii) The ground wheel slip should not be more than 10 per cent.

viii) The sowing machine should be able to drop seed upto 10 cm depth and 2.5 cm side to fertilizer.

ix) The field preparation in which the machine has to be tested must be in desired condition.

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CHAPTER III

THEORETICAL CONSIDERATIONS

Every machine is expected to do its work accurately for which it is meant. The machine as a whole is composed out of the number of different components which does its specific function irrespective of the others. Like the other machines, the sowing or planting machine is also prepared by the composition of various components which perform their specific functions in different conditions with wide variations. To get the different functions done by the components, they should be designed accurately for their shape, size and the material to be used. This chapter is dealt with the theoretical considerations for the design of the cotton planter.

3.1 Feed Sets

The function of the feed sets is to form a layer of seeds fed from the box and also to shift it simultaneously aiside and push into the seed tubes stream-like. In fluted roll and studed roll, the feed set consist of two parts, the rotary element displacing seeds also called as feed roll, and immobile guiding surface called the bottom. The slot between the roll and the bottom is to a greater or lesser extent filled with seeds. The feed rolls and the bottom plate are protected by walls fixed on either sides of the box, forming what is called a feed cup.

Volume of seeds fed by one flute as accepted theoretically is expressed by the following equation.

$$V_t = (F_1 + F_2)\ l = Fl \text{ (Cu Cm)}$$

Where F_1 and F_2 - areas of cross sections of the one flute(sq.cm)

l - length of the flute(cm)

The volume V_o of seeds fed by one turn of the fluted roll can be calculated either by assuming the required quantity (in kg)of seeds of stated bulk density Y (in kg/cudecim)fed per hectare, inter-row width a (in cm), Driving wheel diameter D_k(in m)and total drive transmission ratio i, or assuming value D(in m) d(in m), l (in m)and the number of flutes Z.

The volume V_o of seed fed by one turn of the roll can be calculated by the equation:

$$\frac{\Pi D_k \ Q \ ha \ a}{1000 \ yi} = \frac{V_o'}{i} \text{(Cu cm)}$$

whereas the volume of seeds fed by one turn of the ground wheel(drive wheel)is

$$V_o' = \frac{\Pi D_k \ Q \ ha \ a}{1000 \ y} \text{ Cu Cm.}$$

The actual total volume of seeds delivered by one turn of the roll by taking into account the active layer is expressed as

$$V_{rs} = (E \ F_z' + \Pi D_s')$$

Where $F = F_1 + F_2$

E = the co-efficient of filling flutes with seeds

l = active length of the roll

z'= number of flutes

The value of E depends on the size and shape of seeds as also flute profiles and on the directions of feeding grains to cups.

$$F_1 + F_2 = \frac{D^2}{8}(\alpha_1 - \sin\alpha_1) + \frac{r^2}{4}(\Psi_2 - \sin\Psi_2)$$

$$\alpha_1 = \text{arc}\ \sin\frac{b}{D}$$

$$\Psi_2 = 2\ \text{arc}\ \sin\frac{b}{2r}$$

$$b = D\ \sin\frac{\pi}{2} - \quad b$$

Assuming D, d and 1 (cm) as given in figure and taking into consideration the volume of seeds displaced by flutes

$$V_1' = \frac{\pi}{4}\, l\ (D^2 - d^2)\ \text{cu cm.}$$

The total volume of seeds sown by one turn of the roll accepted in theory is

$$V_s = \frac{\pi}{4}\, l\ (\ (1-a)(D^2-d^2)+4(D+S)+S)\ \text{cm cm.}$$

Since the actual volume of seeds removed is always somewhat lower than the theoretical value V_o then $V_{rz} = B\ V_o$(B is the coefficient of material feed reduction equal to 0.6 - 0.8)the volume of seeds fed during one turn of the ground wheel of the drill is equal to

$$V_{rz}' = \frac{\pi}{4}\, ln'\ \beta((1-\quad)\ (D^2-d^2)+4(D+S)^s\ \text{(cu.cm.)}\ \ldots\ldots(I)$$

where n' is the number of revolutions of the feed roll per turn of the ground wheel.

To relate the parameters of the feed set with the quantity of seed sown per hectare, the following euqation can be used.

$$Q\ ha = Vha\ Y\ \text{(kg/hectare)}\ \ \ldots$$

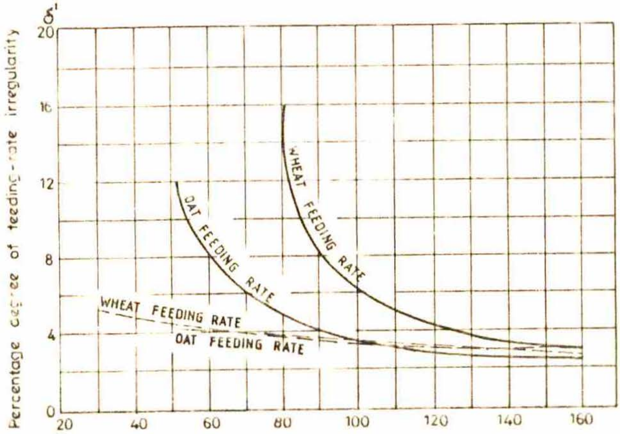

Fig 3.1 Example of variation in the index of seeding irregularity δ' as a function of the seeding rate for fluted unit (dashed lines) and for studed unit (full lines).

where Vha is the volume of seeds sown out per hectare. The area of sown during the travel of per metre amounts to

$$A = S_r lm = Z_a l \quad (sq.m.) \qquad .... \qquad (II)$$

After substituting in the above expression values for V'_{rz} and for obtained from the euqations I and II, respectively, we get

$$Qha = 10,000 \frac{a\ ln'\beta(1-a)(D^2-d^2) + 4S\ (D+S)}{4d}$$

From this epxression we are able to calculate the outer diameter of the feed roll as follows.

$$D = K\sqrt{\frac{Z_a\ Q\ ha}{2800\ y\ \Pi\ (1-a)\ \beta\ l\ n'}}, \quad ... \ (III)$$

Where K is the coefficient which takes into account the width of the slot. For Fluted rolls K = 0.80 - 0.90 and for studed rolls K = 0.90 - 0.98

When making the use of formula(I)and (III), it is necessary to adopt coefficient a = 0.30 - 0.40.

3.2 Resistances and Efficiency of Drills

The weight of drills depends on their working width, the type of machine and the design solutions of individual types. It may be assumed that the specific weight G' for horse drawn drills vary within limits of 190-230 kg/m. In mounted drill of shorter longitudinal dimensions G' = 130 - 180 kg/m. Approximately 85 per cent of weight falls to the rear axle and some 15 per cent to the fore-carriage axle.

The drills total resistance in operation(Total draft Pu) amounts to

$$P_u = P_k + P_r + P_t$$

where P_k - rolling resistance of wheels

P_r - resistance of openers in operation

P_t - friction resistance in bearings and drive gear transmission.

As is well known, P_k depends on the value of reaction of soil, therefore, on loading of wheels, the type and state of soil and the type and dimensions of the wheels. Since the moment required to put in motion the moving parts of the drill is relatively low, it may in calculation of consumption power, be altogether disregarded. In other words P_k can only be considered for traction wheels during transport. Reaction of the soil to the wheels with openers lowered.

$$R' = G_1 + Q + G$$

where Q = weight of seeds

G = weight of operator

G_1= G i r' weight of the drill with lowered operating openers

i = number of openers

r' = vertical reaction of soil to a hoe opener

In the case of hoe openers, the direction of operation of this component as known changes 3 - 3.5 kg. The rolling resistance of a semi-mounted drill in motion is calculated according to the simplified equation.

$$P'_k \quad \frac{D_k}{2} R'_f = 0$$

Where

$P_k' = R'$ - horizontal component of soil reaction (rolling resistance in motion)

R^I - Vertical component of soil reaction

D_k - wheel diameter

f - arm of rolling friction dependent on dimensions, type and state of the soil and the speed of the travel.

Hence

$$P_k' = \frac{2R' f}{D_k}$$

The resistance of the travelling drill during sowing

$$P_k = f\ P_k' = (G_1 + Q + G)\ f'$$

where f' is the coefficient taking into account the value f and the friction resistances in bearings, in practice $f' = 0.12 - 0.22$.

3.3 Flow of Seeds through Drill Tubes

The motion of the seeds through the drill tubes is governed by the laws of free fall of a body. However, the motion of a seed is affected by its aerodynamic properties, friction, impact on the wall of the drill tube and design features and dimensions of the tubes. It is difficult to consider all these parameters. Hence, for practical purposes, we may assume that the motion of the seed is represented by that of a freely falling body with the influence of all other factors being accounted for by an overall coefficient.

The differential equation for the motion of the seed may, therefore, be written as

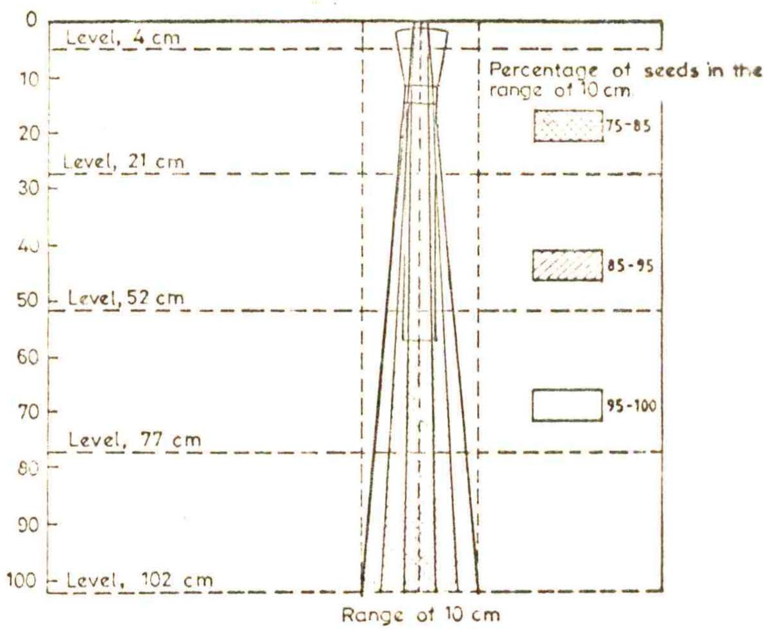

Fig 3.2 Example of spreading of freely falling seeds from different heights.

$$m \frac{d^2z}{dt^2} = G$$

On integrating we get, $\frac{dz}{dt} = gt + c$,

Where c is the constant of integration equal to the vertical component Uv, of the velocity with which the seed is delivered by the feed unit substituting C = Uv we get $\frac{dz}{dt} = gt + Uv$

Integrating again

$$Z = gt^2/_2 + U_vt$$

If Z is equal to Hd, the length of the drill tube, the duration for which the seed is in residence within the tube is

$$t = - Uv \pm \sqrt{V_v^2 + 2 \text{ Hd } g} \; ;$$

(For feed units of seed drills $U_V = 0$)

To consider the rest of the factors affecting the motion of seed, let us assume that $t_m = \mu t$,

where t_m is the time required for the motion of the seed through the drill tube. This accounts for the factors affecting the free fall of the seed.

μ is a coefficient which varies from 1.05 to 1.15 for drill tubes during sowing and 1.3 - 1.45 for furrow openers of square row or hill drop seed drills.

3.4 Furrow Opener

The direction of operation of the forces affecting a hoe opener is different from that of the shoe opener. In the hoe type opener, the reaction of the soil is directed at a certain angle of its horizontal component R' coincides with that of the weight G of the system. Consequently, if the upper soil layer offers an increased resistance, the opener

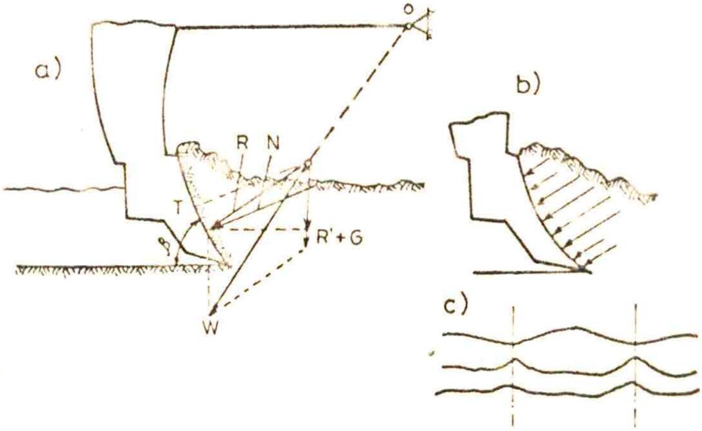

Fig. 3.3 a) Forces acting on a hoe opener; b) reaction of soil to the forming of a furrow by an opener, c) example of displacement of the upper soil layer after passing of an opener.

shows no tendency towards running shallow or even rising entirely over the soil surface as is the case in openers with an obtuse angle β. It is thereoire apparent that a hoe opener is better adopted for cultivation of compact and lumpy soils.

Since the resultant $\vec{W} = \vec{R} + \vec{G}$ is directed to the horizontal plane at a greater angle than in the case of shoe opener. The resistance of a hoe opener amounts to 3-3.5 kg.

3.5 Roller Chain

The power required for the operation of hill drop mechanism seed metering unit and agitator was decided to be transmitted with the help of roller chain from the shaft of the ground wheels.

3.5.1 Drive kinematic

Driver sprocket is assumed to rotate at a uniform speed the driven spocket rotates at a varying speed that fluctuates above and below some average value. Because of the chordal action, the average speed of a sprocket can not be calculated in terms of the pitch diameters but is equal to the length of the chain passing around the sprocket in a unit time.

Thus $$V = \frac{P \times N \times RPM}{376}$$

Where V = average chain velocity m/sec

P = chain pitch, in

N = Number of teeth on sprocket

RPM = sprocket speed, rpm.

Similarly, the speed ratio of a chain can not be calculated in terms of the pitch diameters but can be calculated from

$$\frac{RPM_1}{RPM_2} = \frac{N_2}{N_1}$$

For simplicity, the chain length is calculated in terms of the pitches, and the result is multiplied by the chain pitch to obtain the actual chain length.

The approximate length of a chain drive in pitches is

$$L = 2C + \left[\frac{N_2 + N_1}{2}\right] + \frac{(N_2 - N_1)^2}{4\pi^2 C}$$

Where C = Centre distance in chain pitches

N_2 = Number of teeth on bigger sprocket

N_1 = Number of teeth on smaller sprocket.

The approximate length, if fractional, must be modified to a whole, and preferably, to an even number of pitches. The centre distance may be corrected for the revised chain length by solving the above equation.

The exact chain centre distance of a chain drive in pitches is

$$C = \frac{L - \left[\frac{N_2+N_1}{2}\right] + \left\{\left[L - \left(\frac{N_2+N_1}{2}\right)\right]^2 - \frac{(N_2-N_1)^2}{4\pi^2}\right\}^{\frac{1}{2}}}{4}$$

The pitch diameter of a sprocket is $PD = \frac{P}{\sin\left(\frac{180}{N}\right)}$

Where P = chain pitch, in

N = Number of teeth on the sprocket

3.5.2 Chain forces

The chain pull or working load can be calculated as follows.

$$CP = 1000 \frac{P}{V}$$

Where P = Power Kw

V = Chain velocity m/sec.

The force rating for a single strand chain can be determined by the following empirical equation.

$$F = 0.273\ P^2 \left\{ 5100 - 115\ V^{0.41} \left[1 + 25 \left(1 - \frac{\cos 180}{N} \right] \right\} \right.$$

Where F = Force lb.

P = Chain pitch, in.

V = Chain velocity ft/min.

N = Number of teeth on the sprocket

At lower speeds, the horse power capacity is determined by the fatigue life of the link plates, and is calculated as follows.

$$HP = 0.004\ N_1^{1.08} n_1^{0.9} p^{3.0} - 0.007\ P$$

Where N_1 = Number of teeth in the smaller sprocket

n_1 = speed of the smaller sprocket, rpm

p = Chain pitch, in.

3.6 Design Consideration for the Shaft

The shaft of the ground wheel is subjected to combined twisting moment and bending moment. According to maximum shear stress theory, the maximum shear stress in the shaft.

$$f_s(max) = \tfrac{1}{2}\sqrt{f_b^2 + 4\ f_s^2}$$

Substituting the values of fb and fs

$$f_s(max) = \tfrac{1}{2}\sqrt{\left(\frac{32M}{\Pi\ d^3}\right)^2 + 4\ \left(\frac{16T}{\Pi d^3}\right)^2}$$

$$= \frac{16}{\Pi d^3}\sqrt{M^2 + T^2}$$

The expression $\sqrt{M^2 + T^2}$ is known as equivalent twisting moment and is denoted by T_e .

$$T_e = \sqrt{T^2 + M^2}$$

$$= \frac{\pi}{16} f_s d^3$$

From this expression the diameter of the shaft(d) may be evaluated. Now according to maximum normal stress theory, the maximum normal stress in the shaft.

$$f_b(max) = \tfrac{1}{2} fb + \sqrt{(\tfrac{1}{2} fb)^2 + f_s^{\,2}}$$

$$= \frac{32}{\pi d^3}\left[\tfrac{1}{2}\left(M + \sqrt{M^2 + T^2}\right)\right]$$

or $$\frac{\pi}{32} fb(max)\, d^3 = \tfrac{1}{2}\left(M + \sqrt{M^2 + T^2}\right)$$

The expression $(\tfrac{1}{2}(M + M^2 + T^2)$ is known as equivalent bending moment and may be written as

$$M_e = \tfrac{1}{2}\left(M + \sqrt{M^2 + T^2}\right)$$

$$= \frac{\pi}{32} f_b d^3$$

3.7 Design of Transportation Ground Wheel

The transportation of ground wheel as a whole is composed of axle, hub and spokes which are given in the subsquent paragraphs.

3.7.1 Design of axle

Maximum Bending moment = $\frac{Pl^2}{2}$

Where,

P = Pressure on axle

l = Length of hub

We know $M = \frac{Pl^2}{2}$

f = permissible bending stress in mild steel = 1000 kg/cm^2

Sectional modulus, $Z = \frac{M}{f}$

for solid circular section

$$z = \frac{\Pi D^3}{32}$$

$$D = 3\sqrt{\frac{32Z}{\Pi}}$$

3.7.2 Design of hub

Design equation = $di = d + 2C$

where,

di = Internal diameter of hub, in cm

d = dia of axle in cm.

c = Clearance between the hub and axle

Now P = Pressure intensity in kg/cm^2

$$P = \frac{Load}{di \times L}$$

Where, L = length of hub in cm, load is due to weight of implement

Factor of safety = 2

$$\frac{\text{Total load}}{\text{axle}} = \frac{\text{W x factor of safety}}{\text{number of wheels}}$$

The thickness of the hub is calculated by the equation

$$t = \frac{Pd}{2f}$$

Where, P = pressure intensity in kg/cm^2

d = dia of shaft, cm

f = bending pressure, kg/cm^2

Outer dia of hub

$$do = di + 2t$$

3.7.3 Design of spoke

$$M = W \times ct\left(\frac{D}{2} - \frac{d}{2}\right)$$

where W = vertical load on each wheel

Factor of safety - 4

$$W = \text{Total load} = \frac{\text{Vertical load x factor of safety}}{\text{number of wheels}}$$

Ct = Coefficient of friction

D = dia of wheel

d = dia of hub

M = Bending moment = f.z.

Where z = Modulus of section = $\frac{\pi}{32} d^3$

d = dia of spoke in cm

f = bending stress

$$M = f \frac{\pi}{32} d^3$$

Design of rim thickness

Design equation

$$t = \frac{PD}{2f}$$

where P = soil reaction, kg per cm^2

$$P = \frac{W}{A} = \frac{\text{Total load in kg}}{\text{Area of contact of wheel with , } cm^2}$$

$$W = \frac{\text{Load on one wheel x factor of safety}}{\text{number of wheels}}$$

A = Rim width x distance between two consecutive spokes

D = Dia of wheel

f = bending stress

...

CHAPTER IV

MATERIAL AND METHODS

The selection of material is governed by the following important conditions.

1. Suitability of the material for satisfactory working conditions during operation.
2. Amenability of the material to the easy process required in making the components.
3. Reliability during process and operation or service.
4. Cost of the material in relation to selling price of the component of machine or implement.

The selection of material for the various components of the planter was made after checking the ISI test code No. IS 6813/1973 and the related literature for planter.

The following paragraphs gives an account of fabrication of various components alongwith engineering drawings based on calculations for strength and power requirement. The constructional details are presented in the following order.

4.1 Constructional Details of the Components

1. Frame
2. Ground wheel
3. Transmission for seed metering
4. Seed metering unit
5. Hopper or seed boxes
6. Seed tubes
7. Hill drop mechanism
8. Furrow openers
9. Clutch
10. Hitch and beam.

4.1.1 Frame (1 & 2)

A hollow square bar was prepared by joining the 35mm x 35m x 4mm M.S.angle for the tool bar having length of 1350 mm on which the furrow openers were attached by means of 'U' bolts(40mm x 30mm and 12mm dia)so as to adjust any required row to row spacing. At a appropriate distance, a 35mm x 35mm x 4mm, four pieces were welded normal to the previously mentioned hollow square tool bar, so that both ground wheels could be supported by means of a shaft and axle.

To connect the hitch and beam at a centre of tool bar, the two 45cm long 35x35x4mm angles were joined form a tringle. For supporting the seed boxes, seed metering unit, hill drop mechanism, clutch and transmission system 5 boxes of angle length each having 40cm 30x30x3mm size were connected by nut and bolts vertically on the above mentioned frame.

4.1.2 Ground wheel

For required plant spacing to be achieved by the seed metering devices and for proper hill dropping arrangement the diameter of the ground wheel was selected as 58 cm. Considering the diameter of the ground wheel, a rim width was selected as 100mm to get the maximum traction to drive the feeding unit and hill dropping mechanism.

The rim of the ground wheel was made of M.S.flat of 100x6mm size which was connected to the hub by means of 12mm square bars. The hub of one of the ground wheels which was used for transmitting the power from ground to the seed

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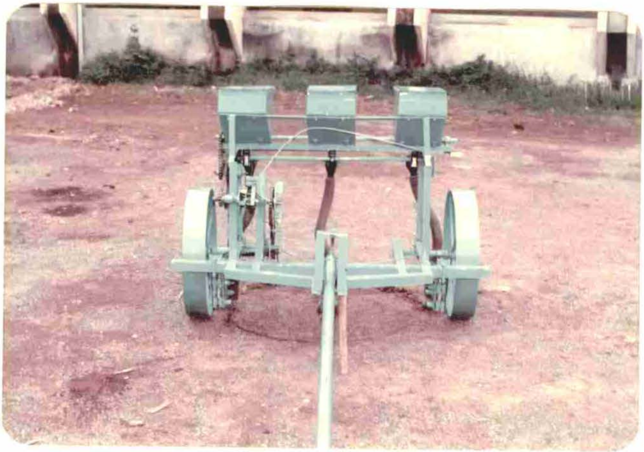


Front view of cotton planter

Rear view of cotton planter.

Plate 4.1

metering unit, was of 25mm hollow square section for mounting on a square shaft tangentially rigid and axially free for adjusting the row to row spacing with the help of spacer. Other wheel was mounted on a 25mm circular axle with the help of bushes and spacer. Axial movement of the ground wheel on the shaft and axle were checked by 15mm check nut. The wheel base was adjusted according to the row spacing with the help of spacer.

4.1.3 For varying peripheral speed of the studed roller( ) five 14 teeth, two 18 teeth, one 21 teeth, one 24teeth and two 28 teeth sprockets were prepared from 5mm thick m.s.plate on the milling machine as per the selected chain pitch of 12.5mm. The roller chain was used with the above chain pitch. The 14 teeth sprocket was mounted on ground wheel shaft, clutch output shaft, final drive output shaft, studed roller shaft and agitator shaft. One 28teeth sprocket was mounted on the clutch input shaft, on which cam plate for hill drop mechanism was also mounted with the help of nut. Another 28 teeth sprocket was mounted on the input of final drive shaft.

Other 18 teeth, 21 teeth and 24 teeth sprockets were used for different peripheral speeds of the studed roller by replacing the clutch output sprocket which can be easily replaced by removing the nut and pressing the automatic chain tensioner.

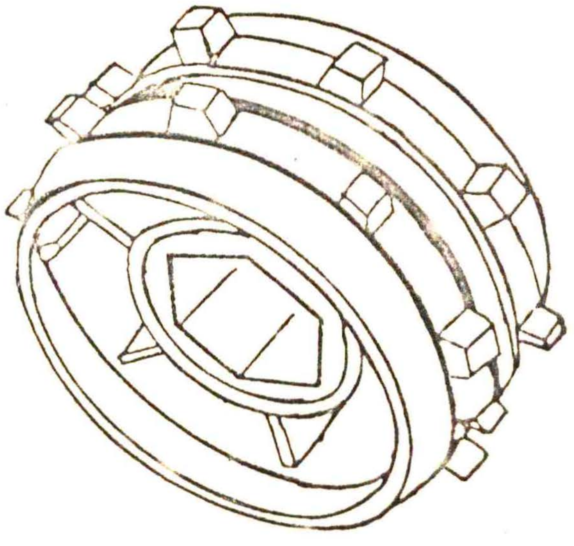


Fig. 4.2 Peg type seed metering device.

By mounting 14 teeth sprocket on clutch output shaft, the speed ratio would be reduced to 4:1 with ground wheel to studed roller shaft, whereas, by mounting 18 teeth sprocket in place of 14 teeth sprocket the speed ratio would be 4:1.28 (ground wheel to final drive or studed roller shaft). Similarly by mounting 21 teeth sprocket, the ratio would be 4:1.5 and with 24 teeth sprocket 4:1.71 speed ratio.

However, any sprocket could be mounted on any shaft and hence there would be 50 combinations from the above 11 sprockets which gives 42 speed variations. The arrangement of the automatic chain tensioner was useful for immediate replacement of sprocket and it could achieve any required chain length.

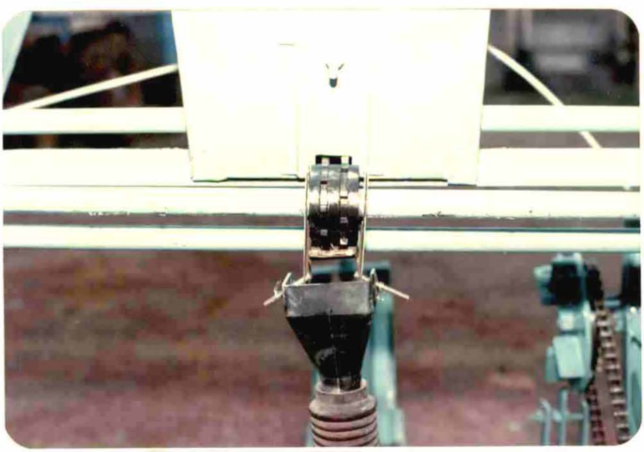
4.1.4 Seed metering unit

As the seed rate of the cotton is very low i.e. from 2.5 to 10 kg/ha and vary with different varieties and soil types, the studed roller was used to meter the seed, because it shift the seed by frontal shifting of the stud. The studed roller made of polyamide with 18 stud on its periphery in two parallel lines. Such three studed r llers were mounted on a shaft prepared from 20mm dia. m.s.pipe on which 14 teeth sprocket was mounted with the help of special nut and bolt prepared from 20mm dia m.s.bar.

4.1.5 Hopper or seed boxes

The three hoppers made of 26 gauge G.I.sheet, as per the shape given in figure were mounted on an angle and flat with the help of nut and bolts. A common agitator shaft

Side view of cotton planter



Seed metering unit.

Plate 4.2

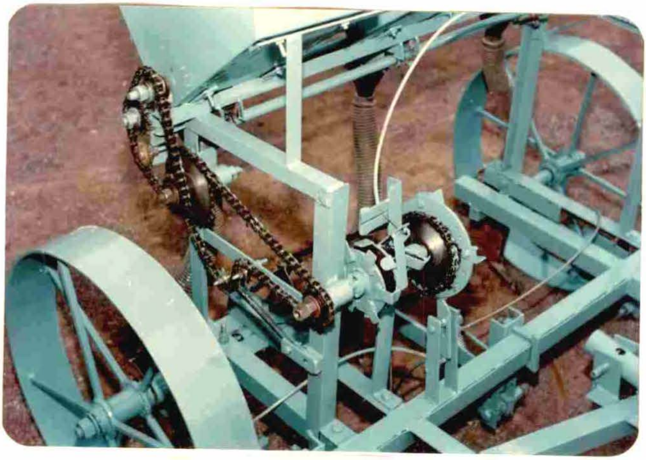
was mounted in the boxes on which studed agitator were mounted just above the sluice value for seed outlet. The volume of each box was about 0.0122 cu.m. which could carry about 5.5 kg. of delented cotton seed at its full capacity with ¾th filling capacity which was about 4 kg. These hoppers were provided with the lids.

4.1.6 Seed tubes

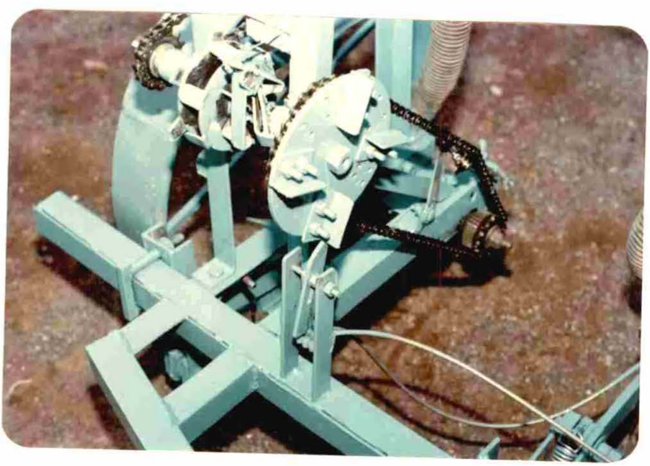
Just below the seed metering unit, a plastic funnel was attached on which 40 mm dia corrugated rubber tube was attached. The maximum streched length was about 45 cm. The row to row spacing was adjusted by the minimum seed tube deviation.

4.1.7 Hill drop mechanism

For hill dropping a flap type spring loded boot value was attached just behind the furrow opener. The valve was rested on seed cell of 30mm dia m.s.pipe attached with the seed tube at upper end and the lower end was closed by the spring loded valve. These three valves of three furrow openers were connected with a lever by means of mobike brake cable. The lever was so hinged just below the cam plate that the opening of valve could be adjusted as desired. A circular plate of 15cm dia. was used as a cam plate on which there was an arrangement to fix 2,3,4,5,and 6 cams at a time with the help of nut and bolt which could maintain a desired plant to plant spacing. This cam plate was driven by the chain and sprocket from the ground wheel. The speed ratio for this was



Transmission system.



Clutch and cam plate assembly.

Plate 4.3

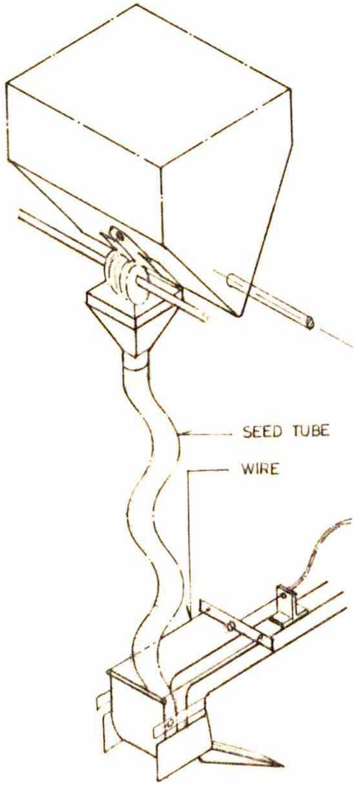


Fig.4.3

Isometric of metering and hill drop mechanism.

2:1(ground wheel to cam plate).

4.1.8 Furrow openers

Three hoe type furrow openers were fabricated out of 45mm x 10mm flat. The shape of the furrow openers was 'C' type, keeping 30° angle with the horizontal plane. It was connected to the tool bar with the help of four bar linkage and 'U' bolts. The four bar linkage was loaded with spring to control the depth. The wing was provided on both side of the furrow openers(were provided)to keep the boot valve soil free for its easy operation.

4.1.9 Clutch

Two circular plates of 10cm dia were used for interlocking the two free shafts. One of the circular plates was with six flats equally welded normal to the plates surface and with a 25mm square hole to mount axially free on the input shaft. Other circular plate was also fabricated with six flates equally spaced and welded on the plane of the plates and rigidly welded to the output shaft. The spring was provided in between these two plates.

Two helical plates were used to press the axially free plate to interlock with other plates to transfer the power to the other shaft. The shifting of clutch was achieved by means of the clutch cable. However, the release of clutch plates was achieved by means of a release spring provided in between these two plates.

4.1.10 Hitch and beam

As the planter was to put in the field and would have to operate parallel to the ground level for a bullock pair of any height, a beam was hinged at its end by nut and bolt in the clits. The height of the yoke point could be adjusted with the help of nut and bolt vertically resting on the beam, for adjusting downward and upward movement of the beam. This nut bolt was joined at the top of two parallel 22cm angles which restrict the lateral movement of the beam. For beam, 40mm dia G.I.pipe with a length of 2.75m was used.

4.2 Working Principles or Operation of the Planter

The rotation of the ground wheel(4)drives the metering unit(view BB)through the shaft and sprocket subassemblies, clutch(15), transmitting unit resulting in seed dropping into the seed cell through the seed tube(5). The seed metering unit discharge 2 to 3 seeds of cotton on its 1/8 revolution. During this 1/8 revolution of the metering unit, the ground wheel moves ½ of its peripheral distance, by which the cam plate(view AA)moves to its ¼ revolution hence one cam conies in contact with the lever (view AA)and pushes it back. On the other end of the lever two or three cables (as per the row spacing)are connected, which opens the boot valve(12)and allow the seed in the seed-cell to drop into the just opened furrow. Immediately after this the boot valve closes the seed cell by means of spring. Due to this peculiar arrangement of the cam and lever,

4.3 Testing

Testing of cotton planter was carried out in laboratory and field. The procedures are described in the following paragraphs.

4.3.1 Laboratory testing

For laboratory testing, three varieties of cotton seeds i.e. AKH-4(Deshi)linted, DHY-286 linted and delinted were used.

For the variety AKH-4, all hoppers were filled with 1 kg. of seed. The boot valves were kept open by locking the cam lever. The planter was raised from the ground, keeping its level parallel to ground. Three pieces of cloths were placed below the furrow openers to collect the metered seed. The transmission ratio was set on its 5th setting (i.e.2:1 ground wheel to studed roller shaft). The ground wheel from which power was taken, was marked at certain point to count its revolutions. After making the equal opening of all seed boxes, 55 revolutions of the ground wheel were made with a constant speed. Samples were collected from all furrow openers and weighed on the balance separately.

In the second test for the cotton seed of variety DHY-286(linted), the position of the planter was kept same as in the first test. Previous seed from the seed boxes were removed and the 1 kg.seed of DHY-286 variety was placed in each seed box. Cam lever was kept unlocked. Transmission was set on its first setting(i.e. at 4:1 ground wheel to studed roller). On the cam plate four cams were attached at equal peripheral distance. Theoratically this setting of hill drop mechanism gives 90 cm. plant to plant spacing with a cluster of 2 to 3 seeds.

The ground wheel was rotated for its 55 revolutions. Samples from all the three furrow openers were collected after each boot valve opening and counted the number of seed in each cluster and recorded. The total collected samples from each furrow openers were weighed on the balance separately.

In the third test the delinted seed of variety DHY-286 with 74 per cent germination was used. For the germination test, 100 seeds were taken randomly and germinated in laboratory. Previous seed was removed from the boxes and filled with 1 kg. of delinted seed of variety DHY-285 in each box. Other settings were kept unchanged. Same procedure was adopted and the samples from each furrow openers were taken and weighed on the balance separately. Randomly 100 seeds were taken from the all the three samples of metered seeds for the germination test.

4.3.2 Field test

The cotton planter was tested on the farm of Agril. Engineering, P.K.V., Akola on an area of 0.2 hectare. The size of the field was 80m x 25m.

The planter was attached to the bullock pair alongwith the proving ring by means of rope. Hill drop mechanism was unlocked. Sluice gate of the hopper were open to certain opening. The seed metering bottom flap were adjusted and the clutch was engaged. Delinted cotton variety of DHY-286 was used by filling 1 kg. of seed in each seed box. Transmission was set on its first setting(i.e. 4:1, ground wheel to seed metering unit). The planter was operated in the field by one labour. The following observations were made during field test.

1. Moisture content of soil
2. Measurement of pulling force
3. Speed of operation and time required for turning
4. Depth of placement of seed
5. Ground wheel slip
6. Field capacity
7. Field performance index
8. Hill spacing and row to row spacing
9. Number of plants observed in each hill

4.3.2.1 Moisture content of soil

Five samples were collected randomly at a depth of 15cm from the plot and the moisture content of each sample was calculated by gravimetric method by using the following formula.

$$\text{Moisture content (d.b.)} = \frac{W_1 - W_2}{W_2} \times 100$$

Where, W_1 = Initial weight of soil sample

W_2 = Oven dry weight of soil sample

4.3.2.2 Measurement of draft

Calibrated proving ring having capacity to measure force ranging from 0-500 kgs was attached between the cotton planter and yoke by means of a rope and divisions were recorded during operation of cotton planter at an average speed of 1.6 Km per hour of bullock pair. Three observations were taken in each pass of planter along the row. Such

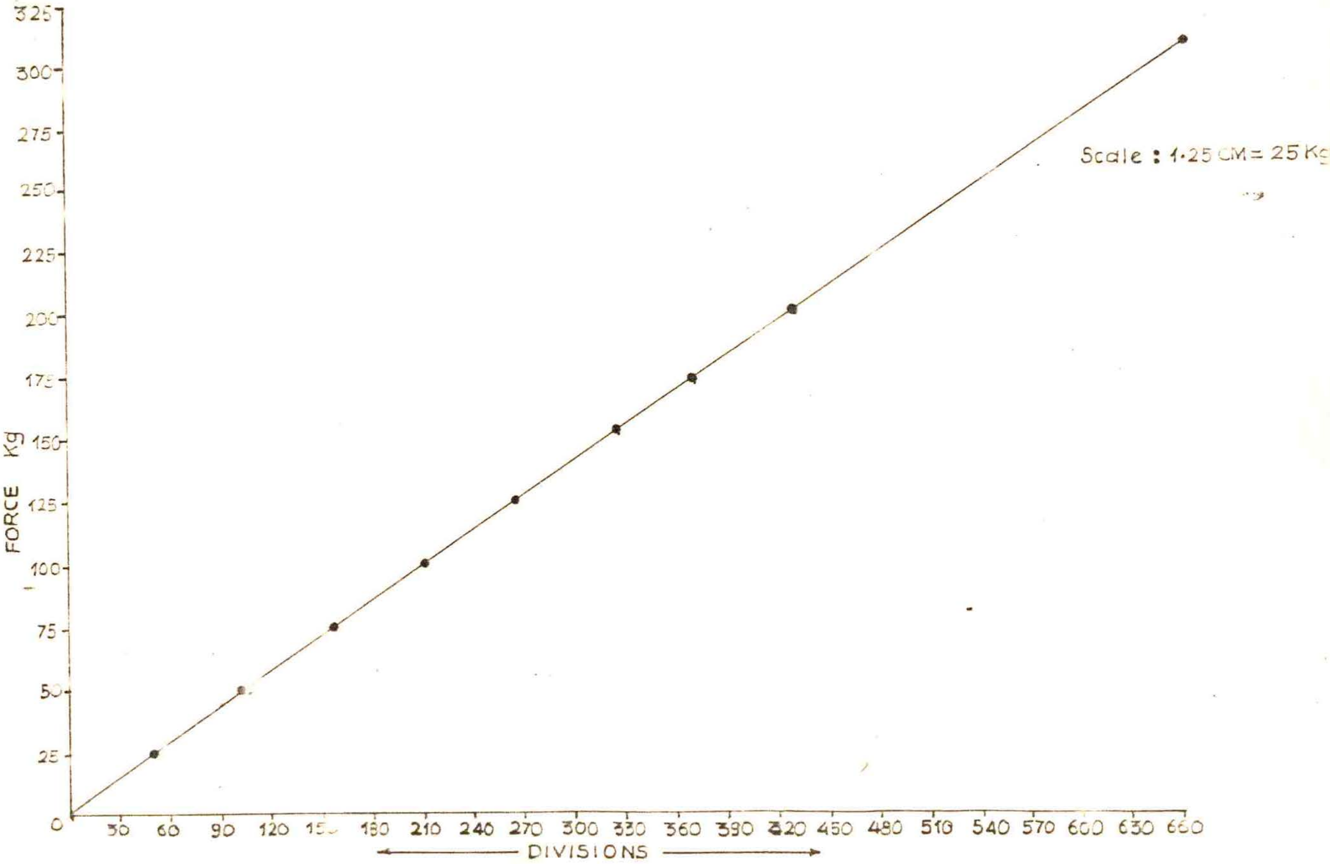


FIG. NO.4·4 : CALIBRATION CHART .

15 observations were taken in randomly selected five rows.

4.3.2.3 Measurement of speed of operation and turning time

The speed of the bullock pair during operation of the cotton planter was measured by recording the time required to cover 80 metre distance. Also time required for turning the cotton planter was recorded.

4.3.2.4 Depth of placement of seed

The loose soil on the observed hill drop, randomly selected, in a row was removed till seeds observed in the furrow. By placing flat horizontal on the ground level, the depth of seed was measured by metre rule. Such observations were taken from entire field, randomly selected at one place in each planter row during operations.

4.3.2.5 Ground wheel slip

For determination of ground wheel slip, number of revolutions of the ground wheel from which power has been taken were counted in a 80 metre length. Five such observations were recorded during the operations from entire field.

4.3.2.6 Field capacity

The field capacity includes theoretical field capacity and actual field capacity.

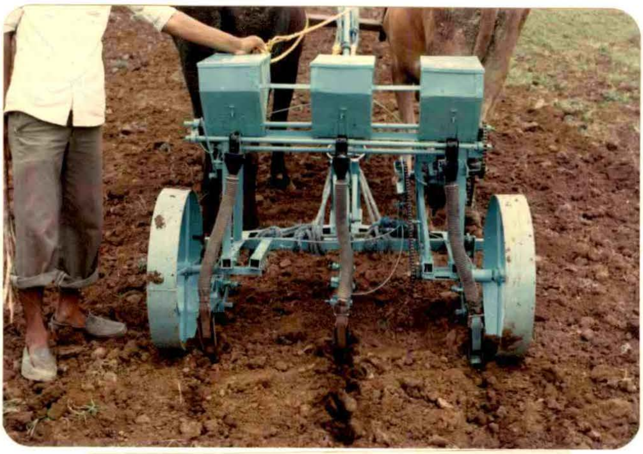
4.3.2.6.1 Theoretical field capacity

The theoretical field capacity was determined by taking the theoretical width covered by the planter and it is equal to the row spacing multiplied by number of rows

Field trial of cotton planter

Measurement of Pulling force.

Plate 4.4



Furrow openers in operation.

Plate 4.5

covered. The time required to plant the seed in a row length of 80 metre was recorded and the speed in kilometer per hour was calculated. The theoretical field capacity was determined by using the formula as follows:

$$\text{Theoretical field capacity (ha/hr)} = \frac{\text{Theoretical width (M)} \times \text{Speed Km/hour}}{10}$$

4.3.2.6.2 Actual field capacity

The planter was continuously operated in the field for the specific time period. The length and width of test plot was measured and the area covered during the testing period was determined. The actual or effective field capacity was expressed in hectare per day.

4.3.2.7 Field performance index

The field performance index was determined by using the values of the theoretical and actual field capacities. The field performance index of machine was given by

$$Ef = \frac{To}{T_e + T_h + T_a} \times 100$$

Where, To = Time required to covery one hectare theoretically

T_e = Time required to cover one hectare considering overlap.

T_h = Time lost in turning

T_a = Time lost in filling seed hopper and other interruption

4.3.2.8 Hill spacing and row to row spacing

The distance between hills in a row was measured with the help of steel tape after germination i.e. 10 days after sowing at randomly selected 100 hill pairs. Similarly the distance between two rows was measured with the help of steel tape at the same time at randomly selected 100 places.

4.3.2.9 Number of plant observed in each hill

Number of plant in a hill was counted at randomly selected 100 hills and recorded.

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CHAPTER V

RESULT AND DISCUSSION

The bullock drawn cotton planter was tested in the laboratory as well as in the field to assess its accuracy in seed metering, hill dropping, mechanical damage and germination percentage. Cotton AKH-4(linted), DHY-286(linted and delinted)varieties were used for the above tests which is presented through the following paragraphs.

Test procedure was followed as per ISI standard (IS 6813-1973) and the result and discussion is given in the standard format.

5.1 Seed metering test for Deshi Cotton

While conducting the laboratory test, the variation in seed metering mechanism per furrow opener varied from 65gms to 78gms(average of five replications)(Table-5.1)which corresponds to 55 revolutions of ground wheel of the planter and 100 m^2 area under test theoretically. This gave the seed rate of 21.5 kg per hectare as against recommended seed rate of 15 to 20 kg per hectare. Thus, it indicated the seed rate at high setting. The percentage of variation was 7.5 per cent above the recommended seed rate since the metering mechanism was set at higher metering level. It is clear that the recommended seed rate could be accomodated and the planter has acceptable accuracy of the metering mechanism. For the other varieti s also the seed metering could be properly adjusted and thus it was observed that the planter was accurate within the tolerance limit.

Table: 5.1- Observation of metering of Deshi cotton of AKH-4

Furrow openers	weight of seed metered	Variation in percent
1st	72 gms	10.7
2nd	65 gms	-
3rd	78 gms	20.0
Total	215 gms	

So far as the variation between the three metering mechanisms is concerned, it was 10.7 per cent and 20 per cent respectively above the recommended seed rate of 65 gms. The reasoning for variation in the three metering mechanisms was due to linted seed coated with uneven layer of mud and cow dung paste. Moreover seed size also played an important role. In linted seed the seed size variation can not be totally eliminated. However, this variation could be adjusted to bring the uniformity in the seed metering mechanism by adjusting bottom flaps provided at each of the studed rollers. This variation is adjustable. Thus planter takes care of this variation.

5.2 Hill Dropping Test

Cotton DHY-286(linted and delinted) was used for testing the hill dropping mechanism. The seed dropped at each hill dropping of the boot valve were noted and average of 10 droppings were calculated which worked out to be 3.4 to 6 in furrow opener I, 2.6 to 4.9 in furrow opener II and 3.0 to 4.5 in furrow opener III respectively(Table-5.2.1).

Table 5.2.1- Table showing the average of ten observed value of seed dropping for DHY-286 linted seed.

Sr.No.	Furrow openers		
	1st	2nd	3rd
1	3.4	4.8	3.2
2	5.1	4.9	4.9
3	4.0	3.6	4.9
4	4.2	2.8	4.6
5	5.2	3.4	4.2
6	4.0	3.9	3.8
7	4.5	4.5	4.6
8	4.7	4.9	4.6
9	4.0	4.6	3.0
10	5.1	3.6	3.7
11	6.0	3.3	3.1
Average	4.56	4.02	4.05
Average seed per hill	5	4	4

Since these variations for 3x110 droppings i.e. for 100 m^3 area worked out to vary between 4-5 seed per dropping against 3 seed(theoretically)per dropping. This variation for delinted seed was minimised and observed to be 2.6 to 3.0 in furrow opener I, 2.3 to 3.0 in furrow opener II and 2.2 to 3.0 in furrow opener III respectively(Table 5.2.2). It was ascertained that delinted cotton seed gave accurate dropping

Table 5.2.2- Table showing the average of ten observed seed in a cluster for DHY-286 delinted seed.

Sr.No.	Furrow openers		
	Ist	2nd	3rd
1	2.6	2.7	2.8
2	2.7	2.9	2.6
3	2.9	2.7	3.0
4	2.7	2.3	2.7
5	3.0	3.0	2.8
6	2.4	2.5	2.4
7	2.7	2.7	2.4
8	2.7	2.7	3.0
9	2.9	2.9	2.8
10	3.1	2.7	2.2
11	2.7	2.7	3.0
Average	2.76	2.70	2.7
Average seed per hill	3	3	3

of average 3 seeds per dropping. Thus it could be concluded that the delinted seeds gave better hill droppings over linted seeds in the cotton planter.

Germination percentage was tested to check the mechanical damage, if any, while passing through the metering mechanism, seed tubes and boot valve. The observed germination percentage is given in Table 5.2.3. The variation in germination prior to metering the seed and after metering

Table 5.2.3- Germination percent of seed before and after metering from the planter.

Furrow openers	Germination percent before metering	Germination percent after metering
1st	74	73
2nd	74	74
3rd	74	73
Average	74	73.33

was very low i.e. from 0 to 1.3 per cent which is negligible and it was concluded that the planter could not damage the seed during metering.

5.2 Determination of Pulling Force

The observations of the proving rings are recorded in the table 5.3.

Table 5.3: Pulling force required to pull the planter at an average speed of 1.6 km/hr.

Sr. No.	Divisions observed	Force in kg.
1	170	87.5
2	160	83.5
3	160	83.5
4	175	91.5
5	160	83.5
6	175	91.5
7	150	75.0
8	175	91.5
9	180	95.0
10	190	101.0
11	180	95.0
12	180	95.0
13	180	95.0
14	175	91.5
15	180	95.0
Average	172.66	90.33 kg.

It is seedn from the Table 5.3 that the force of pull varied from 75 to 101 kg.(150 to 190 divisions of proving ring) averaging to 90.33 kg. at an average speed of 1.6 km. per hour. As per the ISI code IS 6813(1973), the draft of animal drawn seed drill per planter, should not be more than 125 Kg f. Observed planter pulling force is well below that of the force recommended in ISI. Thus the planter is not straneous for continuous work to the animal.

5.4 Depth of Placemenr of seed in the Furrow

Depth of placement of seed was evaluated by taking one observation in each planter row. Such 18 observations were recorded in the Table 5.4.

Table 5.4- Depth of placement of seed in the furrow with 34 per cent soil moisture content.

Sr. No.	Expected depth cm.(E)	Observed depth cm(O)	Deviation (O-E)	$x^2=\frac{(O-E)^2}{E}$
1	5.00	5.2	+ 0.2	0.008
2		4.8	- 0.2	0.008
3		4.3	- 0.7	0.098
4		4.5	- 0.5	0.050
5		4.6	- 0.4	0.032
6		4.4	- 0.6	0.072
7		4.8	- 0.2	0.008
8		4.2	- 0.8	0.128
9		5.1	+ 0.1	0.002
10		5.3	+ 0.3	0.018
11		4.8	- 0.2	0.008
12		4.9	- 0.1	0.002
13		4.8	- 0.2	0.008
14		4.8	- 0.2	0.008
15		5.9	+ 0.9	0.162
16		5.3	+ 0.3	0.018
17		5.8	+ 0.8	0.128
18		6.0	+ 1.0	0.200
	Average depth	4.97 cm	x^2	= 0.958

In the table 5.4 the observations are tested with the statistical method of Chi square method for goodness. The depth of seed ranged between 4.2 to 6.00 cm. The average depth of placement of seed was 4.97 cm. It was deviated from -0.8 to +0.9 cm. The Chi square value of the observation was 0.958. The table value of the Chi square at 5 per cent level and with 17 degree freedom is 8.67. The Chi square value of the observations was less than the table value at 5 per cent level. Hence the depth of placement of seed was acceptable. From this it could be concluded that the springs tension which was given to the furrow opener met the requirement. During operation it was further observed that there were no obstraction of the soil to the boot valve and no chocking of boot valve due to soil.

It was concluded that the arrangement of depth control and boot valve met the ISI requirement.

5.5 Ground Wheel Slipage

Ground wheel slip was determined by counting the number of revolutions in the row length of 50 metre. Observations were taken in randomly selected 5 placement rows and calculated from the following expression.

$$\text{Ground wheel slips} = \frac{r_1 - r_2}{r_1} \times 100$$

where r_1 = theoretical revolution of wheel

r_2 = observed revolution of wheel

Observations during operation and the percent slip is given in Table 5.5.

Table 5.5: Ground wheel slip per cent at 34 per cent soil moisture content.

Sr. No.	Expected number of revolutions of ground wheel	observed number of revolutions of ground wheel	Ground wheel slip in percent
1	43.95	40	8.98
2	43.95	41	6.71
3	43.95	39.5	10.12
4	43.95	39	11.26
5	43.95	40.5	7.84
	Average slip per cent		8.98

From the table it was found that the average ground wheel slip was 8.98 per cent at 34 per cent soil moisture content(Appendix-C). Though the ground wheel slip per cent was in acceptable limits even then it is necessary to reduce as precision planting is required for cotton crop.

5.6 Field Performance Index

Table 5.6 indicates the time required to cover each row of 80 m length. In all 18 planter rows were covered. The row spacing was 45 cm. The minimum time required was 2.75 minute and maximum was 3.083 minute. The average being 2.935 minutes to cover the length of 80m row length. The calculated speed ranged between 1.556 to 1.745 Km per hour. The field performance index under specific field dimensions calculated to be 81.98(Appendix-D).

On the percentage basis it was observed that out of the total time for planting operation the time loss in turning was 15.56 per cent.

From the above discussion it was concluded that the field capacity of the cotton planter was acceptable with 0.155 ha. per hour. Thus in a day of 8 hours working, the planter could cover 1.24 ha. per day with one labour.

Table 5.6 Time required to travel 80m. distance and time required for turning during operations.

Sr. No.	Time required to travel distance along the row Min.	Sec.	Time required for turning	Speed Km/hr.
1	3 (3.00)	00	0	1.6
2	3 (3.083)	05	48	1.556
3	2 (2.966)	58	45	1.618
4	2 (2.95)	57	45	1.627
5	2 (2.916)	55	40	1.646
6	2 (2.833)	50	45	1.694
7	2 (2.966)	58	45	1.618
8	2 (2.75)	45	45	1.745
9	2 (2.966)	58	40	1.618
10	2 (2.75)	45	40	1.745
11	2 (2.833)	50	35	1.694
12	2 (2.833)	50	40	1.694
13	2 (2.916)	55	45	1.646
14	2 (2.966)	58	45	1.618
15	2 (2.95)	57	45	1.627
16	3 (3.00)	00	40	1.600
17	3 (3.083)	05	40	1.566
18	3 (3.083)	05	40	1.566
Average	2.935		40.16	1.637
Total time	52.85 min.		12.05	

5.7 Hill spacing, row to row spacing and Plant per Hill

Plant to plant spacing, row to row spacing and number of plants on each hill was observed after germination in the field and recorded(Appendix-G). The data was tested for significance with the Chi square method of analysis of statistics. The significant level for plant to plant spacing was tested at 10 per cent level and for row to row spacing at 2.5 per cent level. The values are given in Table 5.7.

Table 5.7- Chi square values and table values for the observations.

	Plant to plant spacing	row to row spacing	Number of plant per hill
Calculated Chi square value	63.744	1.7987	-
Table value of Chi square at 10 per cent	81.4	-	-
Table value of Chi square at 2.5 per cent level	-	73.4	-
Average	-	-	3.84

* Plant to plant distance significant at 10 per cent level.
* Row to row spacing significant at 2.5 per cent level.

From the table it was concluded that the plant to plant spacing was significant at 10 per cent level. Similarly the row to row spacing was also significant at 2.5 per cent level. The average number of plants per hill were 4.00. The expected plants were 3 to 4 plants per hill which were acceptable.

From the above it was concluded that the planter designed with the specific seed metering and chargeble peripheral speed of the seed metering was considerably acceptable for the hill dropping and precision planting.

After going through the all laboratory and field tests, it could be concluded that the planter designed for the purpose of hill dropping could be acceptable for the delinted cotton seed of any variety with the recommended plant spacing.

The mechanical damages were negligible and acceptable for delinted seed also.

The force required to pull the planter was below the ISI limit and hence it could not be straineous to the animal to work throughout the day.

The field performance index was 91.98 per cent which met the requirement of ISI and hence it could be more economic for planting the cotton.

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CHAPTER VI

SUMMARY AND CONCLUSIONS

Cotton is an important cash crop of Maharashtra State ranks first in growing of cotton crop. Vidarbha is the major cotton growing region in the Maharashtra State. The economy of the Vidarbha farmers depend on the cotton crop.

Due to more row to row and plant to plant spacing, there is a practice to dibble the seed in the field by means of labours with the traditional method which consume more time money. In the traditional method of dibbling of cotton seed, there may be less germination due to improper depth and covering with dry soil.

In view of this, it was felt necessary to design and develop the cotton planter with the following objectives.

1. To design seed metering suitable for drilling of Deshi cotton crop.
2. To design suitable hill drop mechanism suitable to plant the cotton seed of American varieties from 60cm to 120cm plant to plant distance.
3. To design the planter with the adjustable row to row distance from 45cm to 120cm.
4. To design the furrow opener alongwith boot valve to operate suitably in the field at required depth of 5cm, with depth control mechanism.

The machine was designed under ten major parts according to their functions and was fabricated independently which were then assembled. Those are given below.

1. Frame
2. Ground wheels
3. Transmission for seed metering
4. Seed metering unit
5. Hoppers
6. Seed tubes
7. Hill drop mechanism
8. Furrow openers
9. Clutch
10. Hitch and furrow openers.

The machine was bullock drawn, suitable for planting cotton from 1.2m x 1.2m to 0.60 x 0.45m spacing. The transmission ratio for seed metering unit was adjustable with the 1:4 to 4:1 from ground wheel to seed metering unit.

The hill drop mechanism was consisted of boot valve actuated by cam plate. Frequency of boot valve actuation was adjustable with changing the cam on the com plate.

The planter was tested in laboratory as well as in the field to assess its accuracy in seed metering, hill dropping, mechanical damage, field performance index etc. The planter was tested for Deshi cotton of variety AKH-4 and DHY-286 for linted and delinted seed in laboratory and DHY-286(delinted seed)was tested in field.

The conclusions drawn were as follows:

1. The seed metering mechanism metered Deshi seed within the acceptable limit.
2. The hill dropping mechanism was most suitable for delinted cotton than that of linted seed.

3. The damage to seed due to seed metering unit, seed tube and boot valve was negligible.
4. The pulling force was 90.33 kg. which was suitable to continuous operation without straineous to animal.
5. The field performance index was 91.98 per cent.
6. The depth of placement of seed in the furrow was 4.2 to 6cm with the average of 4.9 cm which was acceptable.
7. Plant to plant and row to row spacing in the field was within the acceptable limit.

The overall performance of the planter during the operation in the field was found to be satisfactory without break down.

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CHAPTER VII

SUGGESTIONS FOR FUTURE WORK

1. The exhaustive field trials should be conducted in Kharif season in order to evaluate the performance of the machine.

2. The improvement in ground wheel should be made in order to reduce its slipage.

3. The performance of the hill drop mechanism should be improved by providing the low tension, spring so as to reduce the ground wheel slipage.

4. The planter should also be tested for different crop and for inter row crop drilling with the cotton planting.

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APPENDIX A

Design of transport wheel

To drop the seed at pre-determined spacing the diameter of wheels of planter is taken 58 cm, then wheel is designed only whith following aspects,

i] Design of hub
ii) Design of spoke
iii) Design of rim thickness.

(i) Design of Hub.

Nature of loading - Pressure due to weight of implement

Material of hub - Mild Steel

Design equation - di = d + 2 c

Where,

dia - Internal diameter of hub cm

d - dia of axle in cm

c - Clearance between hub and axle

$\therefore$ di = 2.5 + c (0.1) = 2.7 cm

Now,

P - pressure intensity in kg/cm^2

$$P = \frac{load}{di \times L} = \frac{40}{2.7 \times 10} = 1.48 \text{ kg/cm}^2$$

where,

L = length of hub, in cm load is due to weight of implement

= 80 kg (40 kg for one wheel)

Factor of safety - 2

$$\text{Total load/axile} = \frac{W \times F.s}{\text{No. of wheels}}$$

$$= \frac{80 \times 2}{2} = 80 \text{ kg/axile}$$

The thickness of hub is collected by the equation,

$t = Pd/2f$

P = pressure intensity

d = diameter of axle

t = bending pressure (Assume 2.30 kg cm^2)

$$t = \frac{1.48 \times 2.54}{2 \times 2.30}$$

$= 0.8043$ cm

$-$ 0.8 cm

$-$ 8.0 mm

Outer diameter of hub = d_o = dia + 2 t

$d_o = 2.7 + 2 \times 0.8$

$= 4.3$

Say = 4.5 cm.

2] Design of spoke

Nature of load - bending moment

Material of spoke - Mild steel

Design equation - $M = W \times ct\ (D/2 - d/2)$

Where,

W = Vertical load on each wheel 40 kg

Factor of safety = 2

$$W = \text{Total load} = \frac{\text{Vertical load x factor of safety}}{\text{No. of, wheels}}$$

$$\frac{40 \times 2}{2} = 40 \text{ kg}$$

Ct = Coefficient of fraction = 0.2

D = diameter of wheel = 58 cm

d = diameter of hub = 4.5 cm

Thus,

a = 40 x 0.2 (58/2 - 45/2)

= 214 kg.

Also bending moment

M = F. Z

Z = Modules of section = $\pi/32\ d^2$

Assuming d =1.25 cm

$\therefore$ Z = $\pi/32\ (1.25)^3$

= 0.1917

Now,

f = 700 kg

M = F . Z

= 700 x 0.1917

= 134.19 kg

As this value is less than M = 214 kg from desigmed equation the diameter of 1.25 cm is tolerable.

3] Design of rim thickness

Design equation,

t = PD/2t

where,

P = Soil reaction kg/cm^2

P = W/A

$$= \frac{\text{total load}}{\text{Area of contect of wheel with soil}}$$

$$W = \frac{\text{load on wheel x factor of safety}}{\text{No. of wheels.}}$$

$$= \frac{40 \times 2}{2} = 40 \text{ kg}$$

A = Rim width x distance between two concecutive spoke

(Peripheri/ No. of spkes)

= 10 x 22.776 cm

= 227.76 cm^2

$$P = \frac{40}{227.76} = 0.176 \text{ kg/cm}^2$$

And, b = 10.18 bending stresses

$$t = \frac{P.1756 \times 58 \text{ cm}}{2 \times 10.18} = 0.50 \text{ cm}$$

= 5 mm.

<u>Results:</u>

i) Diameter of wheel	- 58
ii) No. of spàles	- 8
iii) diameter of bub d_o	- 4.5 cm
d	- 2.7 cm
iv) Length of hub	- 10 cm
v) Width of rim	- 10 cm
vi) Length of spàke	- 53.5
vii) Diameter of spke	- 1.25 cm
viii) Thickness of rim	- 5 mm
ix) Thickness of hub	- 8 mm.

****

APPENDIX B

Determination of diameter of shaft

As the shaft of planter is subjected to shear force as well as bending moment, it is necessary to calculated the diameter of shaft assuming both twisting moment and Bending moment.

Bending moment,

= Length of shaft = 35 cm

= Weight of planter = 80 kg

As weight of planter is distributed over two wheels weight on one shaft = 40 kg

Then Bending moment

$$M = \frac{1}{2}\ 35 \times 40 = 700 \text{ kg - cm}$$

$$\text{Torque} = \frac{\text{H.P} \times 4500}{2\pi \times 33} = 5.425 \text{ kg m}$$

$$= 542.5 \text{ kg cm}$$

$$Fs = \frac{600}{\text{kg cm}^2}$$

$$Fb = \frac{1200}{2} = 600 \text{ kg cm}^2$$

Now,

for twisting moment

$$Te = \sqrt{M^2 + T^2} = \sqrt{(700)^2 + (542.5)^2}$$

$$= 885.61 \text{ kg cm}$$

Using $Te = \pi/16\ Fs\ d^3$

$$d^3 = \frac{Te \times 16}{\pi \times F\,s}$$

$$d = \sqrt[3]{\frac{885.61 \times 16}{\pi \times 300}} = 2.46 \text{ cm}$$

and for Bending moment

$$Mc = 1/2 \left(M + \sqrt{M^2 + T^2} \right)$$

$$= 1/2 (700 + 885.61)$$

$$= 792.80 \text{ kg cm}$$

Now using

$$Mc = \frac{\pi}{32} \quad Fb\, d^3$$

$$d^3 = \frac{Mc \times 32}{\pi \cdot fb}$$

$$d = \sqrt[3]{\frac{792.80 \times 32}{\pi \times 600}}$$

$$d = 2.37 \text{ cm}$$

As per twisting moment diameter of shaft cones to be 2.46 cm.

ft which is greater than Bending moment value diameter of shaft conveniently selected as 2.5 cm

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APPENDIX - C

Soil Moisture Content

Sr. No.	Wt.of empty box (gm)	Wt. of bod with soil sample before over drying (gm)	Wt. of box with soil sample after oven drying (gm)	Wt.of soil before drying (W_1) (gm)	Wt.of soil after drying (W_2) (gm)	Moisture content (d.b) in percent	Average M.C. in %
1	68	115.0	102.0	47	34	38.25	
2	64	112.0	99.5	48	35.5	35.20	
3	55	100.0	89.0	45	34.0	32.25	34.00%
4	70	120.0	108.5	50	38.5	29.85	
5	58	99.0	88.5	41	30.5	34.40	

$$\text{Soil moisture content (d.b)} = \frac{W_1 - W_2}{W_2} \times 100$$

$$= \frac{45 - 34}{34.} \times 100$$

$$= 32.35 \text{ per cent}$$

APPENDIX D

Field performance index.of

1. Theoretical field capacity:

$$\text{Theoretical field capacity (ha. per hr.)} = \frac{\text{Theoretical width (m)} \times \text{Speed km/hr}}{10}$$

The planter was designed for plating three rows at a time and row to row spacing was 45 cm, the theoretical width cover by the planter was determined as,

Theoretical width covered = Row spacing x no. of rows

= 45 x 3

= 135 cm

= 1.35 m

The average speed of the planter was 1.637 km/ hour

$$\text{Theoretical field capacity(ha/hr.)} \quad \frac{1.35 \times 1.67}{10}$$

= 0.22 ha per hr.

2. Actual field capacity:

As the planter was operated like drilling, there was no overlapping in the operation. The actual field capacity was found by including turning time. The actual field capacity was found by including turning time. The planter was operated in the field for 1.085 hrs. and are cowered was 2000 square meter i.e. 0.2 ha.

The time lost in turning was 0.2 hours.

Total time to cover 0.2 hectare area = 1.085 + 0.2

= 1.285 hrs.

Actural field capacity (ha. per hr.) = $\frac{\text{Area covered}}{\text{Actual time required to cover the area}}$

$= \frac{0.2}{1.285}$

= 0.155 ha. per hr.

3. Field performance index:

It is given by the equation as

$$Ef = \frac{To}{Te + Th + Ta} \times 100$$

where,

To = Time required to cover one hectare theoretically

$= \frac{1}{0.22}$

= 4.55 hours to cover one hectare area

Te = Time required to cover one hectare considering overlap.

= 0 (as there is no overlap)

Ta = Time lost per hectare due to time taken to turning.

$= \frac{0.2}{0.2}$

= 1 hour

$Th = \frac{To}{k} \times 100$

$= \frac{4.55}{100} \times 100$

$$Th = \frac{To}{k} \times 100$$

$$= \frac{4.55}{100} \times 100$$

$$= 4.55 \text{ hrs.}$$

$$Ef = \frac{4.55}{4.55+1} \times 100$$

$$= 81.98$$

Field performance index = 81.98

*****

APPENDIX- E

Observations of 2nd Test

Sr. No.	Furrow openers		
	1	2	3
1	4	6	5
2	2	8	4
3	1	7	3
4	6	4	3
5	5	2	1
6	3	1	7
7	8	7	4
8	6	4	3
9	1	5	2
10	8	4	0 0
11	6	8	6
12	7	4	9
13	6	4	8
14	5	2	7
15	3	8	2
16	3	3	3
17	8	6	2
18	2	5	7
19	8	2	3
20	3	7	2
21	2	1	7
22	0	6	3
23	5	4	7
24	3	2	9
25	7	7	8

APPENDIX- E

Observation of 2nd Test

Contd...

Sr. No.	Furrow openers			6
	1	2	3	
26	2	1	3	
27	6	2	1	
28	5	4	3	
29	6	6	6	
30	4	3	2	
31	8	2	6	
32	7	6	3	
33	5	2	7	
34	6	5	4	
3535	1	4	6	
36	2	0	4	
37	5	6	8	
38	0	1	3	
39	5	2	3	
40	3	0	2	
41	4	5	6	
42	5	3	2	
43	6	6	8	
44	7	3	3	
45	8	4	5	
46	9	2	7	
47	0	0	2	
48	7	6	3	
49	2	2	1	

Sr. No.	Furrow openers		
	1	2	3
50	4	3	5
51	6	5	4
52	0	2	1
53	7	2	3
54	3	2	1
55	5	6	4
56	2	4	6
57	6	5	3
58	4	3	5
59	2	4	3
60	5	6	8
61	2	3	0
62	4	5	7
63	3	6	4
64	6	4	5
65	4	5	7
66	4	3	6
67	5	2	3
68	4	4	6
69	5	6	2
70	8	7	6
71	8 6	8	6
72	5	2	0
73	5	3	7
74	7	6	6
75	4	7	3

Contd---

Sr. No.	Furrow opener 1	2	3
76	4	7	3
77	0	6	2
78	7	4	3
79	4	5	7
80	4	5	7
81	4	5	2
82	3	7	4
83	5	0	3
84	3	6	4
85	5	4	2
86	4	6	0
87	5	4	6
88	6	5	3
89	0	6	4
90	7	5	5
91	5	6	4
92	4	3	2
93	3	0	5
94	4	2	6
95	5	6	4
96	8	3	0
97	6	4	6
98	4	3	2
99	5	4	3
100	6	2	4
101	7	4	3

Contd.....

Sr. No.	Furrow opener		
	1	2	3
102	6	4	3
103	4	2	3
104	5	2	4
105	6	4	3
106	3	2	4
107	4	3	2
108	5	7	3
109	4	3	2
110	2	4	3

APPENDIX - F

Observed Hill droping of delinted Cotton Variety DHY 286

Sr. No.	Furrow openers		
	1	2	3
1	2	3	2
2	4	2	3
3	3	4	2
4	3	3	3
5	4	3	4
6	2	3	2
7	3	3	3
8	3	2	3
9	2	3	4
10	1	2	3
11	2	3	2
12	3	3	3
13	4	3	2
14	3	4	2
15	4	3	2
16	3	4	2
17	2	3	4
18	3	2	4
19	1	3	2
20	2	1	3
21	2	2	2
22	4	2	3
23	3	2	4
24	3	3	3
25	4	4	3

Contd.... Appendix -F

Sr. No.	Furrow opener		
	1	2	3
26	2	4	3
27	3	3	4
28	3	2	3
29	2	2	3
30	3	3	2
31	2	2	4
32	3	2	4
33	4	3	2
34	3	3	4
35	2	3	4
36	4	3	2
37	2	1	3
38	2	2	1
39	3	3	3
40	3	2	1
41	3	3	3
42	3	2	3
43	3	2	2
44	4	4	3
45	3	4	3
46	3	3	3
47	3	2	3
48	3	4	3
49	3	3	3
50	2	3	2

Contd....Appendix -F

Sr. No.	Furrow opener		
	1	2	3
51	3	2	2
52	2	2	2
53	1	3	3
54	2	2	2
55	3	2	3
56	3	2	3
57	3	3	3
58	2	3	3
59	3	2	2
60	2	2	1
61	2	2	2
62	3	2	2
63	2	3	3
64	4	3	3
65	4	4	3
66	3	2	3
67	2	3	2
68	2	2	2
69	2	3	2
70	3	3	2
71	2	3	3
72	2	2	3
73	4	3	3
74	3	3	3
75	3	3	4
7			

Contd.....Appendix - F

Sr. No.	Furrow Opener		
	1	2	3
76	2	2	2
77	3	3	3
78	3	3	3
79	2	3	3
80	3	2	3
81	3	3	2
82	4	3	3
83	3	3	4
84	3	3	3
85	3	3	2
86	2	2	2
87	3	2	2
88	3	4	4
89	4	3	3
90	1	3	3
91	3	2	2
92	2	2	4
93	3	3	1
94	3	3	3
95	4	3	1
96	4	4	2
97	3	3	4
98	2	2	2
99	4	3	3
100	3	2	2

Contd...Appendix- F

Sr. No.	Furrow opener		
	1	2	3
101	3	3	3
102	2	3	3
103	2	2	2
104	4	3	3
105	3	3	4
106	3	3	4
107	3	4	3
108	2	2	2
109	2	1	3
110	3	3	3

APPENDIX –µ G

Calculations for Chi squars test for significance

E) Expected plant to plant distance distance= 90 cm   Expected row to row distance = 45 cm

Sr. No.	Observed plant to plant distance (cm) (O)	Deviation (O)–(E)	$X^2 = \frac{(O-E)^2}{E}$	Row to Row distance (cm) (O)	Deviation (O–E)	$X^2 = \frac{(O-E)^2}{E}$	No. of plants per hill
1	2	3	664	5	6	7	8
11	96.5	8.5	0.803	45.5	0.5	0.005	5
2	93.0	3.0	0.1	45.0	0.0	0.0	3
3	96.5	6.5	0.469	44.5	–0.5	0.005	2
4	99.5	9.5	1.003	46.5	1.5	0.05	4
5	98.5	8.5	0.803	45.5	0.5	0.005	3
6	97.5	7.5	0.65	45.0	0.0	0.0	3
7	99.5	9.5	1.003	42.5	–2.5	0.139	2
8	100.5	70.5	1.225	42.5	–2.5	0.139	5
9	100.5	10.5	1.225	43.0	–2.0	0.089	2
10	99.0	9.0	0.9	44.5	–0.5	0.005	1
11	95.0	5.0	0.277	45.0	0.0	0.0	3
12	96.5	6.5	0.469	45.5	0.5	0.005	4
13	92.5	2.5	0.069	44.5	–0.5	0.005	2
14	99.5	9.5	0.625	45.0	0.0	0.0	4
15	91.0	1.0	0.011	44.5	–0.5	0.005	5
16	92.0	2.0	0.044	45.0	0.0	0.0	4
17	93.0	3.0	0.1	46.0	1.0	0.022	3
18	98.5	8.5	0.803	45.5	0.5	0.005	2
19	99.0	9.0	0.9	44.5	0.5	0.005	3
20	100.5	10.5	1.225	43.5	–1.5	0.05	4
21	98.0	8.0	0.711	44.5	–0.5	0.005	3
22	99.0	9.0	0.9	45.5	–0.5	0.005	5

1	2	3	4	5	6	7	8
23	99.5	9.5	1.003	45.0	0.0	0.0	4
24	98.5	8.5	0.803	45.5	0.5	0.005	4
25	99.0	9.0	0.9	44.5	-0.5	0.005	5
26	96.5	6.5	0.469	45.5	0.5	0.005	4
27	98.0	8.0	0.711	44.0	-1.0	0.022	4
28	97.5	7.5	0.625	44.0	-1.0	0.022	4
29	98.5	8.5	0.803	43.5	-1.5	0.050	3
30	98.5	8.5	0.803	46.0	1.0	0.022	4
31	99.0	9.0	0.90	46.0	1.0	0.022	5
32	98.5	8.5	0.803	45.5	0.5	0.005	4
33	99.5	9.5	1.003	46.0	1.0	0.022	5
34	100.0	10.0	1.11	45.0	0.0	0.0	4
35	98.5	8.5	0.803	44.5	-0.5	0.005	4
36	98.0	8.0	0.711	46.0	1.0	0.022	5
37	95.0	5.0	0.277	45.0	0.0	0.0	4
38	94.0	4.0	0.18	44.0	-1.0	0.022	3
39	99.0	9.0	0.9	43.0	-2.0	0.089	4
40	97.5	7.5	0.625	42.5	-2.5	0.139	4
41	100.5	10.5	1.225	46.0	1.0	0.022	6
42	98.0	8.0	0.711	43.5	-1.5	0.05	2
43	97.5	7.5	0.625	44.0	-1.0	0.022	2
44	94.0	4.0	0.18	44.5	-0.5	0.005	4
45	95.5	5.5	0.34	45.5	0.5	0.005	5
46	96.5	6.5	0.469	46.5	1.5	0.05	4
47	97.5	7.5	0.625	44.1	-0.9	0.018	3
48	98.5	8.5	0.803	45.5	0.0	0.0	4
49	99.5	9.5	1.003	43.5	-1.5	0.05	4
50	95.5	5.5	0.34	44.5	-0.5	0.005	5

Contd.... Appendix G

1	2	3	4	5	6	7	8
51	98.5	8.5	0.803	45.0	0.0	0.0	5
52	99.0	9.0	0.9	45.0	0.0	0.0	
53	99.0	9.0	0.9	44.5	-0.5	0.005	
54	100.5	10.5	1.225	45.5	+0.5	0.005	5
55	99.5	9.5	1.003	45.0	0.0	0.0	
56	98.5	8.5	0.803	45.0	0.0	0.0	4
57	97.5	7.5	0.625	45.0	0.0	0.0	
58	98.0	8.0	0.711	45.0	0.0	0.0	
59	98.5	8.5	0.803	44.5	-0.5	0.005	
60	97.5	7.5	0.625	45.5	0.5	0.005	5
61	97.5	7.5	0.625	44.5	-0.5	0.005	
62	98.0	8.0	0.711	45.0	0.0	0.0	
63	99.5	9.5	1.003	45.0	0.0	0.0	6
64	99.0	9.0	0.9	46.5	1.0	0.022	2
65	98.5	8.5	0.803	45.8	0.5	0.005	
66	98.5	8.5	0.803	45.0	0.0	0.0	3
67	98.0	8.0	0.711	45.0	0.0	0.0	3
68	99.0	9.0	0.9	45.5	0.5	0.005	
69	96.0	6.0	0.4	43.5	-1.5	0.05	4
70	91.0	1.0	0.011	45.5	0.5	0.005	
71	93.5	3.5	0.38	45.0	0.0	0.0	
72	92.5	2.5	0.069	45.5	0.5	0.005	3
73	95.0	5.0	0.277	45.5	0.5	0.005	3
74	96.5	6.5	0.469	45.5	0.5	0.005	3
75	97.5	7.5	0.625	45.0	0.0	0.0	4
76	91.5	1.5	0.025	44.0	-1.0	0.022	3

1	2	3	4	5	6	7	8
77	92.0	2.0	0.044	44.5	-0.5	0.005	3
78	92.0	2.0	0.044	45.0	0.0	0.0	4
79	91.5	1.5	0.025	45.0	0.0	0.0	1
80	93.5	3.5	0.38	45.0	0.0	0.0	3
81	93.5	3.5	0.38	45.6	0.5	0.005	4
82	99.5	9.5	1.003	45.6	0.0	0.0	5
83	98.0	8.0	0.711	45.0	0.0	0.0	5
84	99.0	9.0	0.9	45.0	0.0	0.0	4
85	97.5	7.5	0.625	45.0	0.0	0.0	4
86	97.0	7.0	0.544	45.5	0.5	0.005	4
87	98.5	8.5	0.803	45.0	0.0	0.0	4
88	99.5	9.5	1.003	45.0	0.0	0.0	5
89	100.5	10.5	1.225	45.0	0.0	0.0	6
90	93.0	3.0	0.1	44.5	-0.5	0.005	4
91	98.5	8.5	0.803	45.0	0.0	0.0	5
92	99.5	9.5	1.003	46.0	1.0	0.022	4
93	95.5	5.5	0.34	46.5	1.5	0.05	5
94	92.5	2.5	0.069	43.5	-1.5	0.05	3
95	98.5	8.5	0.803	43.5	-1.5	0.05	4
96	99.0	9.0	0.9	44.5	-0.5	0.005	4
97	97.0	7.0	0.544	44.5	-0.5	0.005	4
98	98.5	8.5	0.803	47.0	2.0	0.089	5
99	99.0	9.0	0.9	46.0	1.0	0.022	4
100	98.5	8.5	0.803	46.0	1.0	0.022	4
			63.744			1.7987	3.84

VITA

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