DESIGN, FABRICATION AND TESTING OF A UREA SUPER GRANULE APPLICATOR

By

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PROJECT REPORT

Submitted in partial fulfilment of the requirement for the degree of

Bachelor of Technology in Agricultural Engineering

Faculty of Agricultural Engineering & Technology
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Tavanur - 679 573
Malappuram

1993

DECLARATION

We hereby declare that this project report entitled 'DESIGN, FABRICATION, AND TESTING OF A UREA SUPERGRANULE APPLICATOR' is a bonafide record of the project work done by us during the course of B.Tech. Agricultural Engineering programme and that the report has not previously formed the basis for the award to us of any degree, diploma, associateship, fellowship or other similar title of any other university or society.

N.A. Sakkeena Beevi

Tavanur,

22, November 1993.

K.P. Sudheer

CERTIFICATE

Certified that this project report entitled "DESIGN, FABRICATION, AND TESTING OF UREA SUPERGRANULE APPLICATOR" is a record of project work done jointly by Miss N.A. Sakkeena Beevi and Mr. K.P. Sudheer, under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship, associateship or other similar title to them by any other university or society.

Er. Jippu Jacob
Associate Professor & Head
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Machinery & Energy.

Tavanur,
22, November 1993.

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N.A.Sakkeena Beevi

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CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

SYMBOLS AND ABBREVIATIONS

Agric.	- Agricultural
AICRIP	- All India Coordinated Rice Improvement Project
APAU	- Andhra Pradesh Agricultural University
CIAE	- Central Institute of Agricultural Engineering
cm.	- Centimetre(s)
Dept.	- Department
et al.	- and other people
etc.	- et cetera
Engg.	- Engineering
FAAS	- Fujian Academy of Agricultural Sciences
Fig.	- Figure
gm	- Gram(s)
GI	- Galvanised Iron
h	- hour(s)
ha	- hectare(s)
hp	- horse power
ICAR	- Indian Council of Agricultural Research
ie.	- that is
IFDC	- International Fertilizer Development Centre
IFFCO	- Indian Farmers Fertilizer Co-operative Ltd.
INSFFER	- International Network for Soil Fertility and Fertilizer Evaluation for Rice
IRRI	- International Rice Research Institute

J.	- Journal
KAU	- Kerala Agricultural University
kg.	- kilogram(s)
kg/ha	- kilogram(s) per hectare
kmph	- kilometre(s) per hour
Ltd.	- Limited
m	- metre(s)
mm	- millimetre(s)
MS	- Mild Steel
N	- Nitrogen
no.	- number
PU	- Prilled Urea
PVC	- Poly Vinyl Chloride
Pvt.	- Private
Res:	- Research
Rs.	- Rupees
TG	- Transplanting Guide
TNAU	- Tamil Nadu Agricultural University
UB	- Urea Briquette(s)
USG	- Urea Supergranule(s)
USG-N	- Urea Supergranule Nitrogen
viz.	- namely
/	- per
%	- percentage

INTRODUCTION

Agriculture is the dominant sector of Indian economy and contributes to nearly 32 per cent of the Net National Product and accounts for sizeable share of the total value of the country's exports.

Agricultural development implies a shift from traditional methods of production to new Science based methods which includes new technological components viz. high yielding varieties, timely weed control, improved land managenment, scientific water management practices, adoption of suitable pre and post-harvest technology and other aspects of production technology.

Indian agriculture will require to produce 225 million tonnes of food grains to feed an estimated population of over one billion by 2000 A.D. This means an additional production of 55 million tonnes of food grains in the next seven years. To achieve this estimated target, fertilizers has a crucial role to play.

Rice is the staple food for nearly 40 per cent of the world's people. Rice is the most important and extensively cultivated food crop in Kerala. The state of

Kerala has a total area of 30.43 lakh hectares under cultivation of which 2.586 lakh hectare is under rice. (Directorate of Economics, Trivandrum-1993)

Nitrogen, the most crucial neutrient element is considered to be the primary and major component in rice culture and production system. But rice is known for poor utilization of fertilizer nitrogen. Today the rice farmers' practices for nitrogen fertilizer application generally include basal broadcasting with or without incorporation before transplanting and/or one or two top dressings in standing water after transplanting but before flowering (re-productive stage).

Numerous research reports have now demonstrated that these management practices of application of fertilizer nitrogen in transplanted rice are very inefficient. The recovery of applied nitrogen by rice crop has been reported to be as low as 28-34 per cent ie., only about one third of the fertilizer nitrogen is used by the plants, and the rest is lost through ammonia volatilization, nitrification, denitrification, run off, leaching, biological immobilization by soil organic matter and NH_4 fixation by clay mineral. In order to reduce or eliminate the losses of fertilizer nitrogen through different ways there are many probable methods. They are:

1. Split application of N fertilizers.
2. Use of N fertilizers with partial solubility.
3. Use of coated materials like Sulphur Coated Urea, shellac coated urea, Gypsum coated urea etc.
4. Use of nitrification inhibitors like Iso Butylidene Diurea, Crotonylidene Diurea, Urea aldehyde, coaltar and neam cake etc.
5. Application of urea granules of different sizes.
6. Selection of proper N fertilizers.
7. Method and time of N fertilizer application.
8. Reducing percolation rates.
9. Use of slow releasing materials like mud balls, enriched compost pellets.

Urea, the dominant source of N fertilizers, has the chemical formula $CO(NH_2)_2$. It is very concentrated and contain about 46 percent of nitrogen, all soluble in water. It contributes about 80 percent of the total nitrogenous fertilizers produced. Prilled urea is the principal N fertilizer used for transplanted rice. However, this results in low nitrogen use efficiency.

The poor efficiency of fertilizer urea in transplanted rice can be attributed to its improper application by farmers. As an overall consequence of inefficient use and inadequate fertilizer nitrogen application, the rice yields are low, generally 1-2 tonnes per ha. In irrigated rice production, fertilizer N use efficiency can be increased to 40-60percent with the placement of fertilizer at rootzone.

Urea super granule(USG) one of the latest addition to the list of new source of nitrogen fertilizers, holds good promise to improve nitrogen use efficiency in the rice crop. The superiority of USG over best split application of prilled urea is well proven(Subbaiah et al. 1989) through INSFFER Programme, Co-ordinated programme and lead research trials.

Deep placement of USG in transplanted rice is an agronomically efficient and environmentally safe urea use practice as compared to the traditional application methods for prilled urea (PU) (Savant et al. 1990). The application of USG at lowest zones reduces the cost of cultivation by reducing the fertilizer requirement over conventional broadcasting of urea. Also, grain yields of rice can be substantially increased on account of higher fertilizer use efficiency.

At present the following methods are used for deep placement of USG in transplanted rice by the farmers. The methods are

(i) Hand placement during transplanting.

(ii) Hand placement after transplanting.

(iii) Machine placement after transplanting.

The deep placement of USG by hand during and after transplanting is a slow field operation (0.07 to 0.12 ha work per day) Thus requiring much labour. This labour intensiveness and drudgery of placing USG manually have seriously limitted USG adoption by rice farmers in South Asia. Therefore, in the past ten years several attempts have been made in Philippines (Khan et al 1986), China (Lin 1984), India (Bhoopalan 1983), Subbiah 1989) and USA (Savant et al 1990) to develop Quitable USG applicators for deep placement of urea in transplanted rice. A few prototypes have been found to be labour saving and agronomically efficient when tested in research farms.

The non continuous type applicators are of the plunger type. It is the most efficient methods for placing USG in ordinary transplanted rice fields. This method usually uses the dibbling principle. Dibbling is the process of placing USG in holes made in the field and covering them with soil. Urea granules are placed in the holes made to definite depth at fixed spacing. This also reduces the amount of fertilizer requirement.

The placement of USG requires only one aplication as compared to split application of prilled urea in conventional method. When USG is applied with applicator it also reduces nearly 1/4th labour cost of labour force used for transplanting (Subbaiah et al 1989).Thus theuseof USG applicators will have a bright scope in rice culture in India.

Considering the above facts and also the numerous advantages in using a dibbler, it is proposed to develop a manually operated non continuous operation type applicator for deep placement of USG in wetland rice fields with the following objectives.

(i) To design and fabricate a USG applicator with suitable metering mechanism.

(ii) To evaluate its performance in the laboratory and in the field.

REVIEW OF LITERATURE

The details of the studies conducted and reported by various researchers on USG, USG applicators, and other related aspects are briefly discussed.

2.1 UREA MANAGEMENT PROBLEMS

Although urea is competitively priced, it is utilised inefficiently in rice fields especially where fields have inadequate water management. Much of its nitrogen is lost through denitrification, leaching, run off, volatilisation and other mechanism (Fig. 1). The magnitude of loss through a particular mode depends on soil condition, agricultural practices, agro-climatic conditions, type of fertilizers and also methods of their applications. Shinde found the maximum recovery of N in rice crop as 24 per cent.

2.2 REQUIREMENTS IN FERTILIZER APPLICATION

To derive maximum benefit from mineral fertilizers it is essential to comply with the following requirements also with regard to the techniques in their application. (Bulaev, 1984)

(i) Uniform distribution of fertilizers.

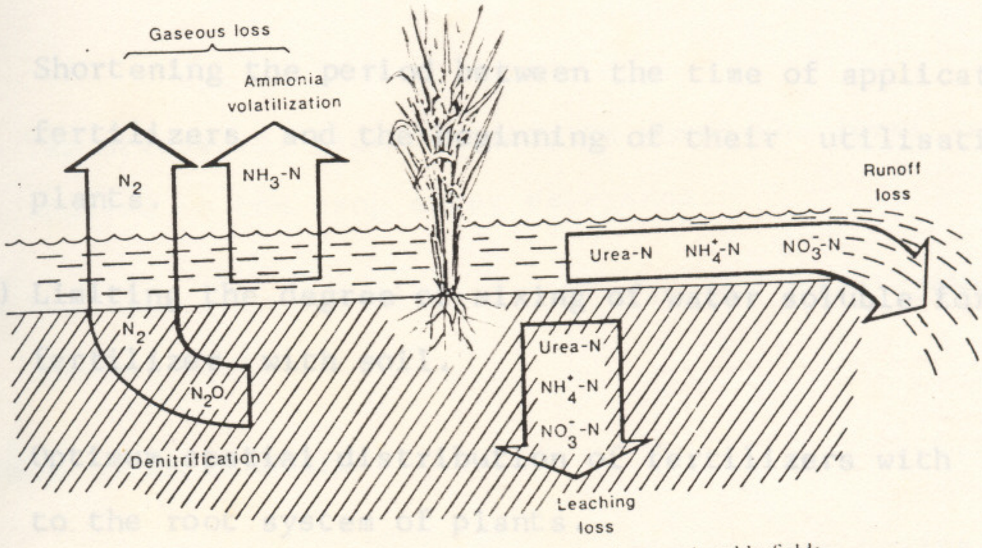

Fig. 1. Pathways of fertilizer N losses from submerged paddy fields.

Fig. 2. Different forms of urea. (1). Prilled urea (2). Spherical USG; (3). Tablet USG; (4). Urea briquettes (pillow shape).

(ii) Shortening the period between the time of application of fertilizers and the beginning of their utilisation by plants.

(iii) Limiting the degree of mixing of water soluble forms of fertilizer with soil.

(iv) Optimum spatial distribution of fertilizers with regard to the root system of plants.

(v) Optimum depth of application in the soil.

2.3 METHODS FOR APPLYING FERTILIZERS

Some of the application methods for applying commercial dry fertilizers are as follows. (Kepner, 1982)

(i) Broadcasted before ploughing or placed at the ploughing depth by a distributor on the plough that drops fertilizer in each furrow.

(ii) Deep placement with chisel-type cultivators.

(iii) Broadcasted and mixed into the soil after ploughing and before planting.

(iv) Applied during the planting operation.

(v) Side band, in which the fertilizer is applied in bands to one or both sides of the seed or plant.

(vi) Top dressed or side dressed, in which the fertilizer is applied to the crop after emergence.

(vii) Drilled into established pastures and other sods with special equipment.

2.4 UREA SUPER GRANULES

The super granules are big in size having 11-14 mm. diameter and weight 1-2 gm. Technological, agronomic and economic considerations suggest that USG fertilizers is an appropriate form of urea fertilizer for use in transplanted rice. So far commercial level production of the super granules has not started in any country. The granules of different shapes are shown in fig (2) in actual size.

2.4.1 Advantages of USG

(i) Convenience in incorporation.

(ii) Lower solubility on account of bigger size meaning lower neutirient losses.

(iii) Lower neutrient losses on account of reduced conversion rate to nitrates.

(iv) Increased downward diffusion of urea, which is another contributing factor for increased use efficiency.

2.4.2. Production and properties of USG

2.4.2.1. Production

There are four main processes for production of granular urea namely Pan granulation, falling curtain, fluid bed and briquetting.

2.4.2.2. Properties

USG fertilizer is a simple physical modification of ordinary urea fertilizer. It consists of large discrete particles of urea ($H_2N\ CONH_2$) containing 46per cent of N as NH_2, an amide form. Their shape and weight depends upon the production process used.

2.5 METHODS OF USG DEEP PLACEMENT

Today, farmers can choose an appropriate method from the following alternatives.

1. Hand placement during transplanting.
2. Hand placement after transplanting.
3. Machine placement after transplanting.

2.5.1. Hand placement during transplanting

This can be done by IFDC dispenser method. In this method, USG is also dibbled at the time of transplanting by the same persons. The combined field operation is accomplished using a simple inexpensive bamboo device called USG dispenser with transplanting guide (TG) is shown in fig.3.

The method is summerised as follows: Woirking in a pair, two workers transplant two rows, each consisting of 10 hills, using the 'USG dispenser with TG' (Fig.4a). One worker transfers 10-12 USG to the wire basket located below the USG hopper (Fig.4b). Each worker picks up five USG in one hand (Fig.4c) and inserts all five USG with the other hand, one USG for each four hills to a 7-10 cm. soil depth (Fig. 4d). The workers move about 40 cm straight backward, approximately align the TG, and repeat the combined operation. Before moving backward the workers may have to close the holes at placement sites.

It requires about 25-30 per cent more labour than farmers method of random transplanting and PU application done seperately.

2.5.2. Hand placement after transplanting

There are two methods in this category: (i) Researcher's method and (ii) IFDC TG method

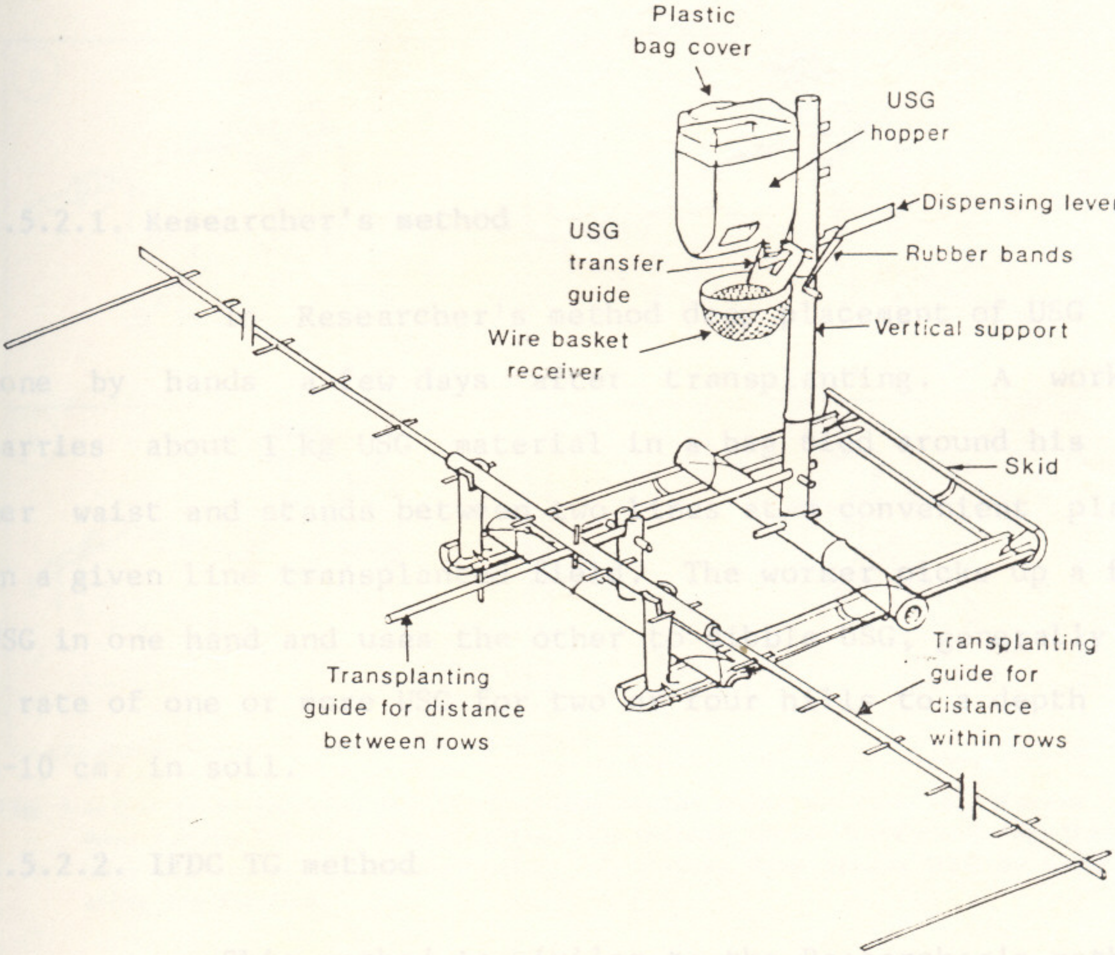

Fig. 3 Sketch of USG dispenser with transplanting guide.

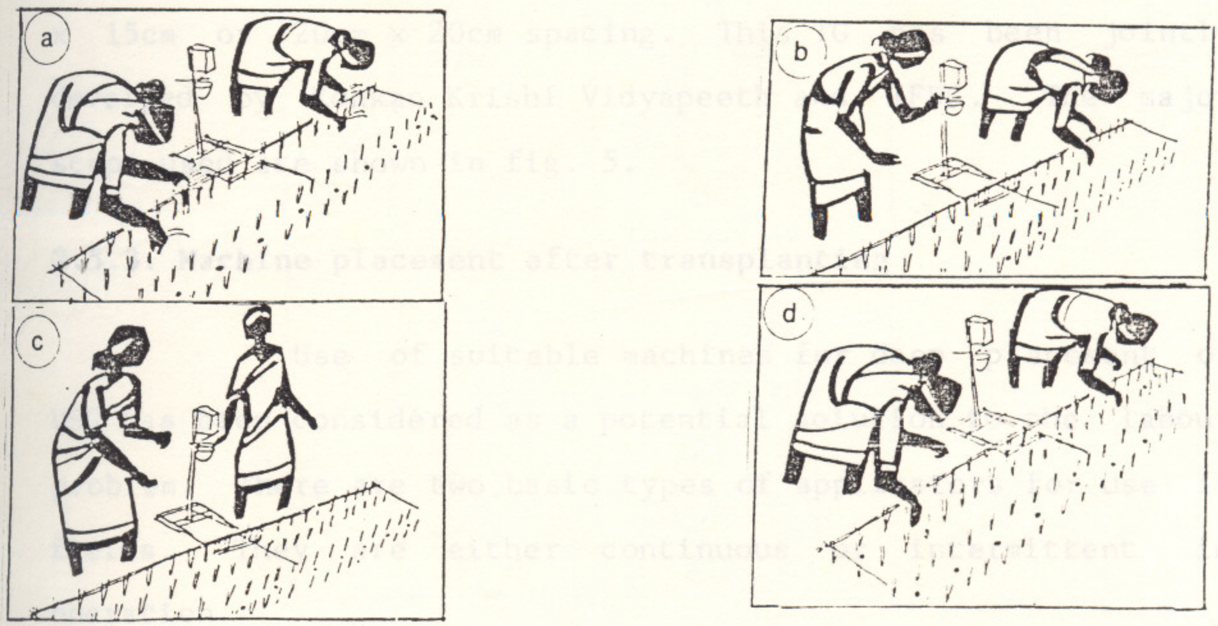

Fig. 4 Major steps in using the IFDC dispenser method. (a). Workers use device for line transplanting ; (b). Workers transfer USG; (c). Workers pick up USG ; (d). Workers deep place USG by hand .

2.5.2.1. Researcher's method

In Researcher's method deep placement of USG is done by hands a few days after transplanting. A worker carries about 1 kg USG material in a bag tied around his or her waist and stands between two lines at a convenient place in a given line transplanted field. The worker picks up a few USG in one hand and uses the other to dibble USG, generally at a rate of one or more USG for two or four hills to a depth of 5-10 cm. in soil.

2.5.2.2. IFDC TG method

This method is similar to the Researcher's method except that transplanters use a simple, inexpensive, home made, bamboo guide for line transplanting with a modified 20cm x 15cm or 20cm x 20cm spacing. This TG has been jointly develped by Konkan Krishi Vidyapeeth and IFDC. The major steps used are shown in fig. 5.

2.5.3. Machine placement after transplanting

Use of suitable machines for deep placement of USG has been considered as a potential solution to the labour problem. There are two basic types of applicators for use in fields. They are either continuous or intermittent in operation.

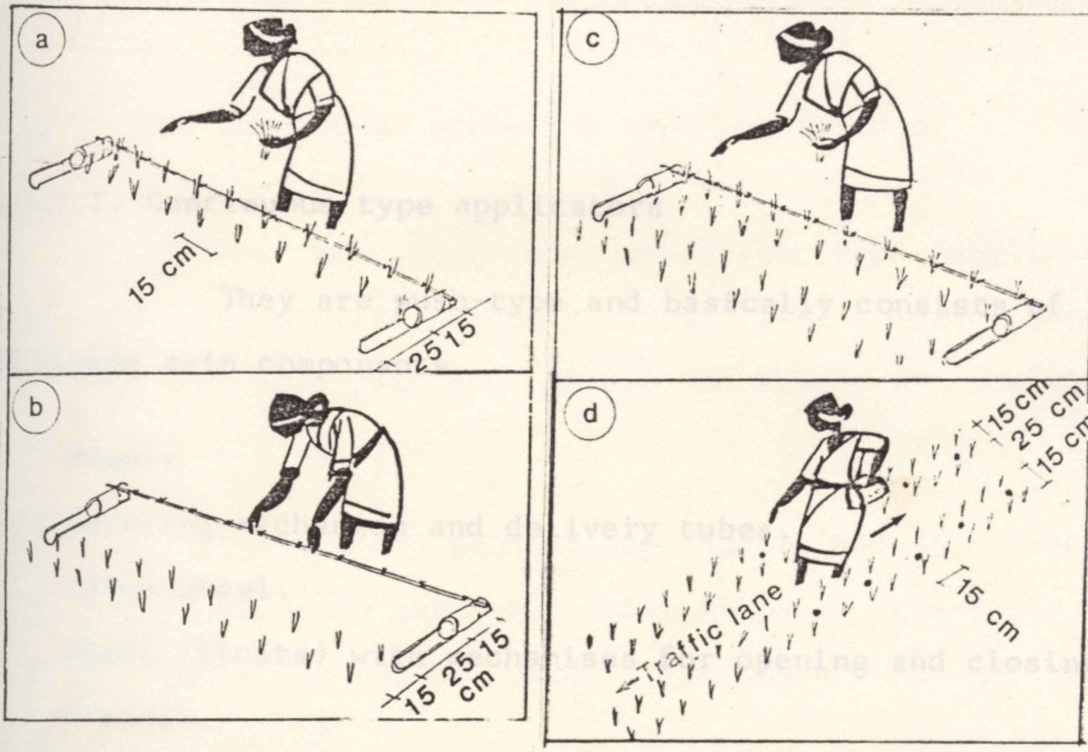

Fig. 5 Major steps in using the IFDC transplanting guide method. (a). Worker uses device for line transplanting; (b). Worker moves backward; (c). Worker uses device for line transplanting; (d). Worker deep places USG by hand using traffic line.

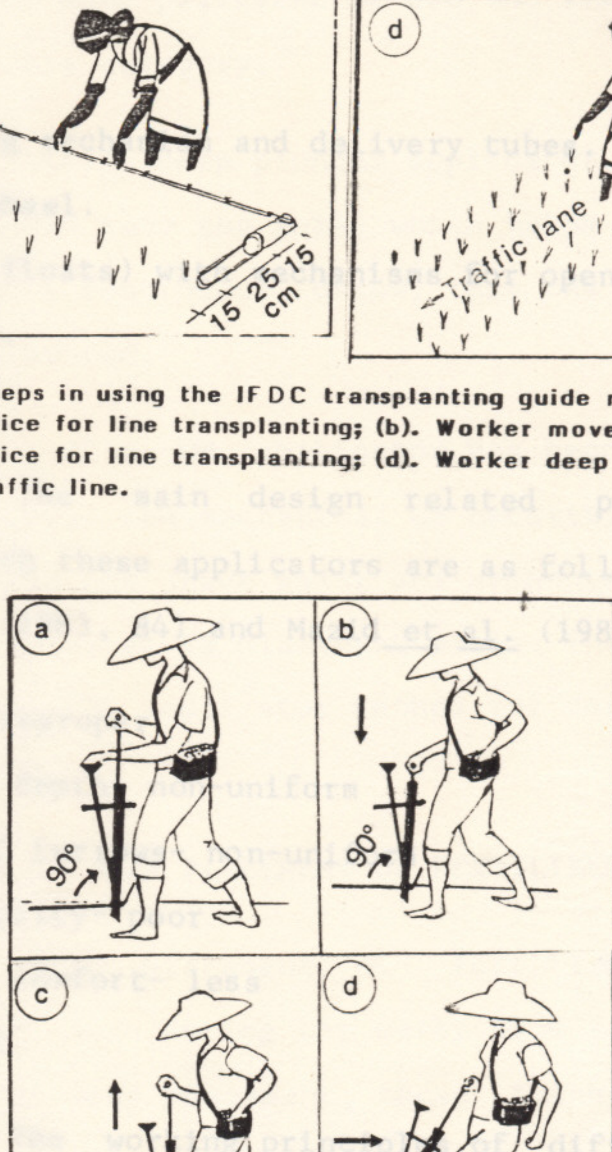

Fig. 6 Four major steps in using the IFDC applicator method for deep placement of UB. (a). Worker places UB in delivery tubes; (b). Worker pushes handle; (c). Worker pulls handle; (d). Worker moves backward .

2.5.3.1. Continuous type applicators

They are push-type and basically consists of the following main components.

1. Hopper
2. Metering mechanism and delivery tubes.
3. Drive wheel.
4. Skids (floats) with mechanisms for opening and closing of furrows.
5. Handle.

The main design related problems normally encounted with these applicators are as follows: (Cochran,B.J. (1985) Khan (1983, 84) and Mazid <u>et al.</u> (1985).).

1. Metering-improper
2. Placement depth- non-uniform
3. Closing of furrows- non-uniform
4. Field capacity- poor
5. Operation comfort- less
6. Cost- high

The working principles of different continuous operation type applicators are given under the heading 2.6.

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2.5.3.2. Non continuous operation type applicators

The non continuous operation type applicators developed are of the plunger type. IRRI's deep plunger applicator for deep placement of USG and IFDC's UB applicator belonged to this category.

IRRI's deep plunger applicator, has an advantage of pushing USG into the soil, which helps to eliminate the need to open a continuous furrow, thus the amount of energy expended is reduced.

IFDC's UB applicator has been accomplished by eliminating (a) the mechanical UB metering device (b) the hopper and (c) the drive wheel and mechanism for opening and closing the holes at UB placement sites. The four major steps in using the IFDC applicator method for deep placement of UB is shown in fig.6.

2.6. HISTORY OF DEEP PLACEMENT OF FERTILIZERS

Deep placement of fertilizers for rice was practised in Japan during the early 1930's. On the basis of the nature of deep placement, these technology developments can be divided into two broad classes:

CLASS I

Deep non-point placement of fertilizer N by dry soil application during or after first ploughing and/or harrowing followed by irrigation or before on set of rain.

CLASS 2.

Deep point placement of fertilizer N as pellets, mudballs, or super granules after or during line transplanting.

Highlights in the development of the present agrotechnology of deep placement of USG in transplanted rice are given below.

Keniebi Sato 1930's, Japanese farmer at Aomori perfecture had practised deep placement of fertilizers.

In the period 1946 to 1949 mechanised deep placement of liquid Ammonia was attempted in Japan. This data was given Wetanabe et al. in 1979.

In the period from 1953 to 1955, 1955 to 1958, 1958 to 1961, mechanical deep placement of liquid fertilizers, prilled urea fertilizer in dry soil, crystalline Ammonium chloride, respectively were found efficient in field experiments attempted by Japanese scientists. This data are given by Wetanabe _et al._ in 1979.

Kunitake (1962) developed simple hand driven device in Japan to deep place prilled urea between hills about one week after transplanting.

De Data _et al._ (1968) determined efficiency of fertilizer N for flooded rice. N studies showed that deep placement of crystalline ammonium sulphate or prilled urea increased rice plant uptake of fertilizer N.

In 1973 Chinese produced one gram ammonium bi-carbonate pellets using a small double roll machine and began field evaluation of Ammonium bi carbonate pellets deep placed at approximately 6 cm depth in transplanted rice. This data are given by Li _et al._ in 1980.

De Datta (1974) conducted experiments on increasing efficiency of fertilizer N in flooded tropical rice. He developed mudball technique for deep point placement for urea after line transplanting and was evaluated by IRRI in the Philippines.

IRRI in 1977 developed plow-sole applicator for deep placement of PU

Ponnayya *et al.* (1979) developed an applicator for placement of fertilizer insecticide mixture at 5-7 cm depth, in Tamil Nadu state.

Khan (1982) developed a device for the deep placement of USG in wetland rice in IRRI at Philippines. The unit is a deep plunger USG applicator. The operation is non continuous and push type. USG are metered and pushed one at a time from the feed tube by a hand-actuated plunger, both mounted on the top of a skid. The applicator does not have a furrow opener. The plunger extents 5 to 7 cms to push USG into the soil. Little covering is required. A single hole 1.25 cm in diameter is made in the soil. A metal spring loaded valve prevents mud intrusion into the feed tube as the plunger is withdrawn.

Boopalan (1983) developed USG applicator for paddy in Tamil Nadu Agricultural University. The applicator has two fluted-type rotors fixed over two floats inside the fertilizer hoppers that are connected to the furrow openers by transparent tubes with 10 degree inclination. The applicator is continuous type and push-type. When pushed forward, USG is dropped one by one into the furrows and are closed by the skid. The applicator weighs 8.5 kg. The dimensions of the applicator is 1400 x 510 x 810 mm. The metering mechanism is rotated by the ground wheel. Furrow openers are provided to

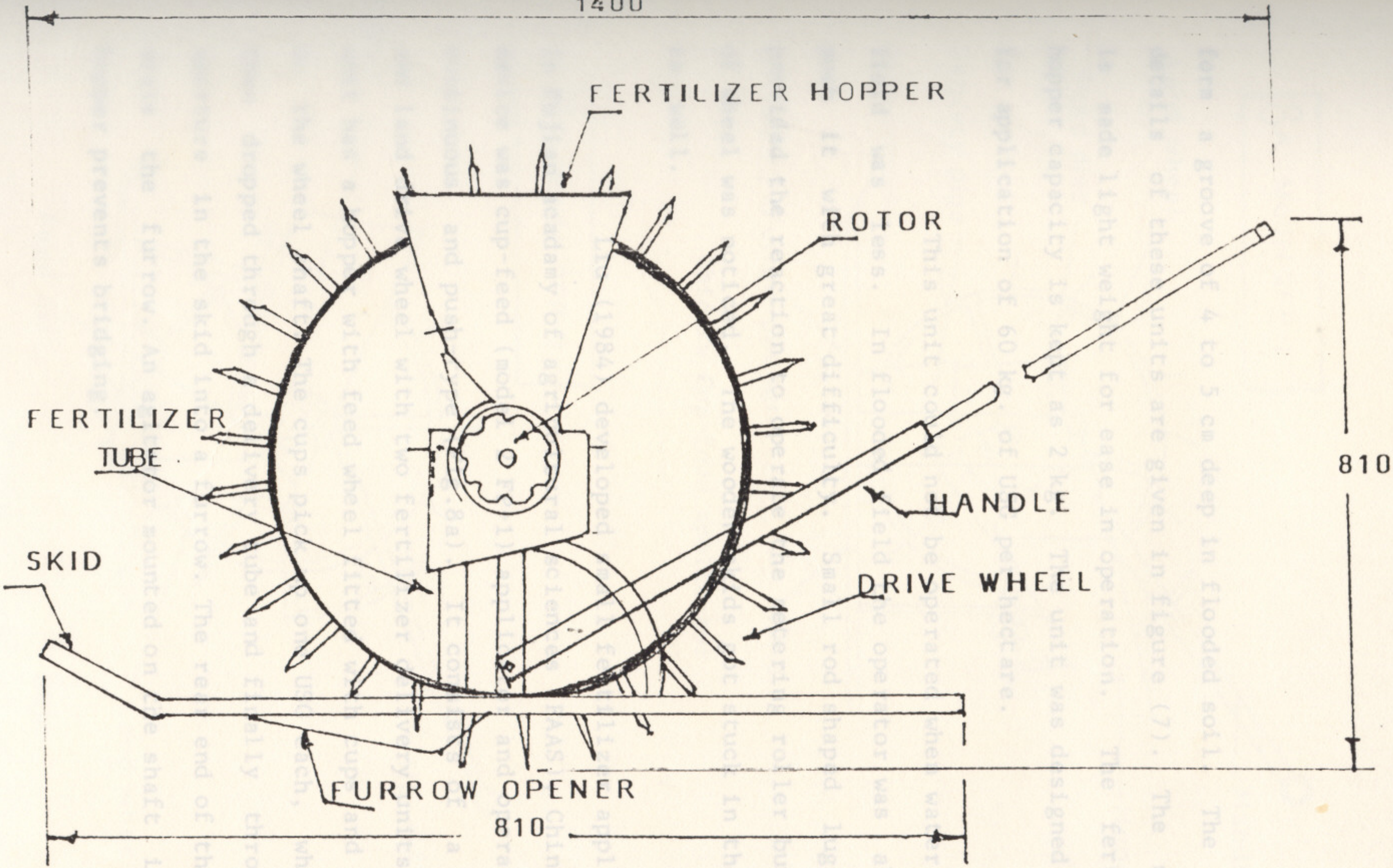


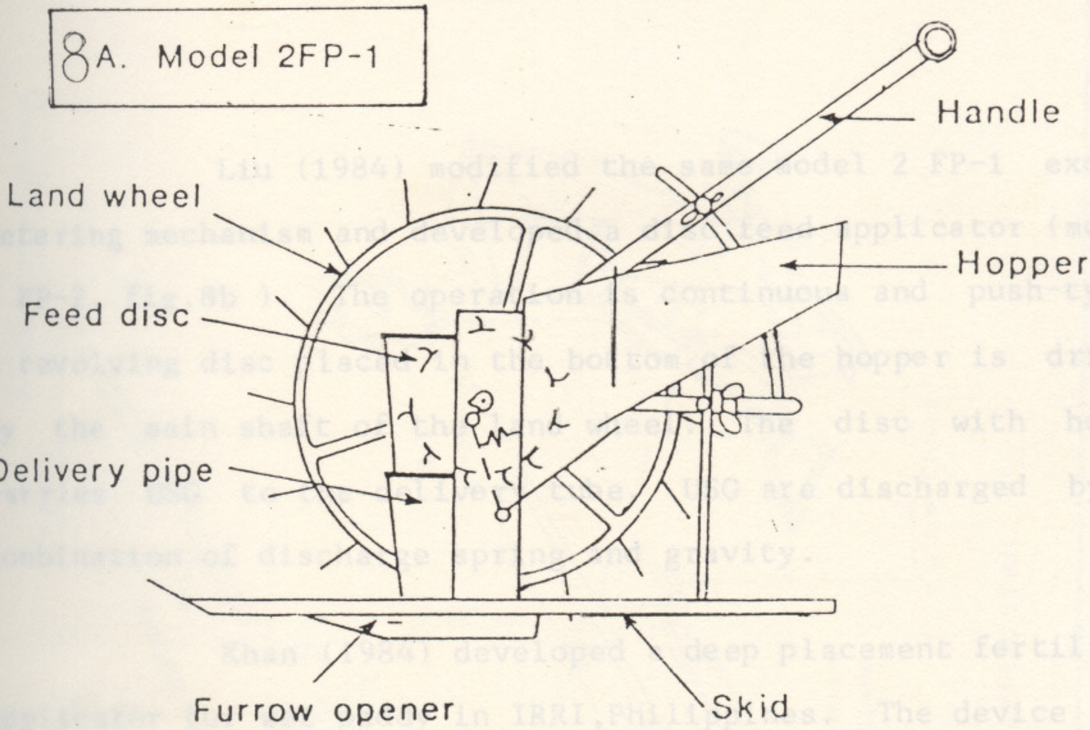
Fig. 7. USG applicator for paddy - TNAU design.

form a groove of 4 to 5 cm deep in flooded soil. The design details of these units are given in figure (7). The machine is made light weight for ease in operation. The fertilizer hopper capacity is kept as 2 kg. The unit was designed mostly for application of 60 kg. of USG per hectare.

This unit could not be operated when water in the field was less. In flooded field the operator was able to push it with great difficulty. Small rod shaped lugs were provided the reaction to operate the metering roller but slip of wheel was noticed. The wooden skids got stuck in the field as well.

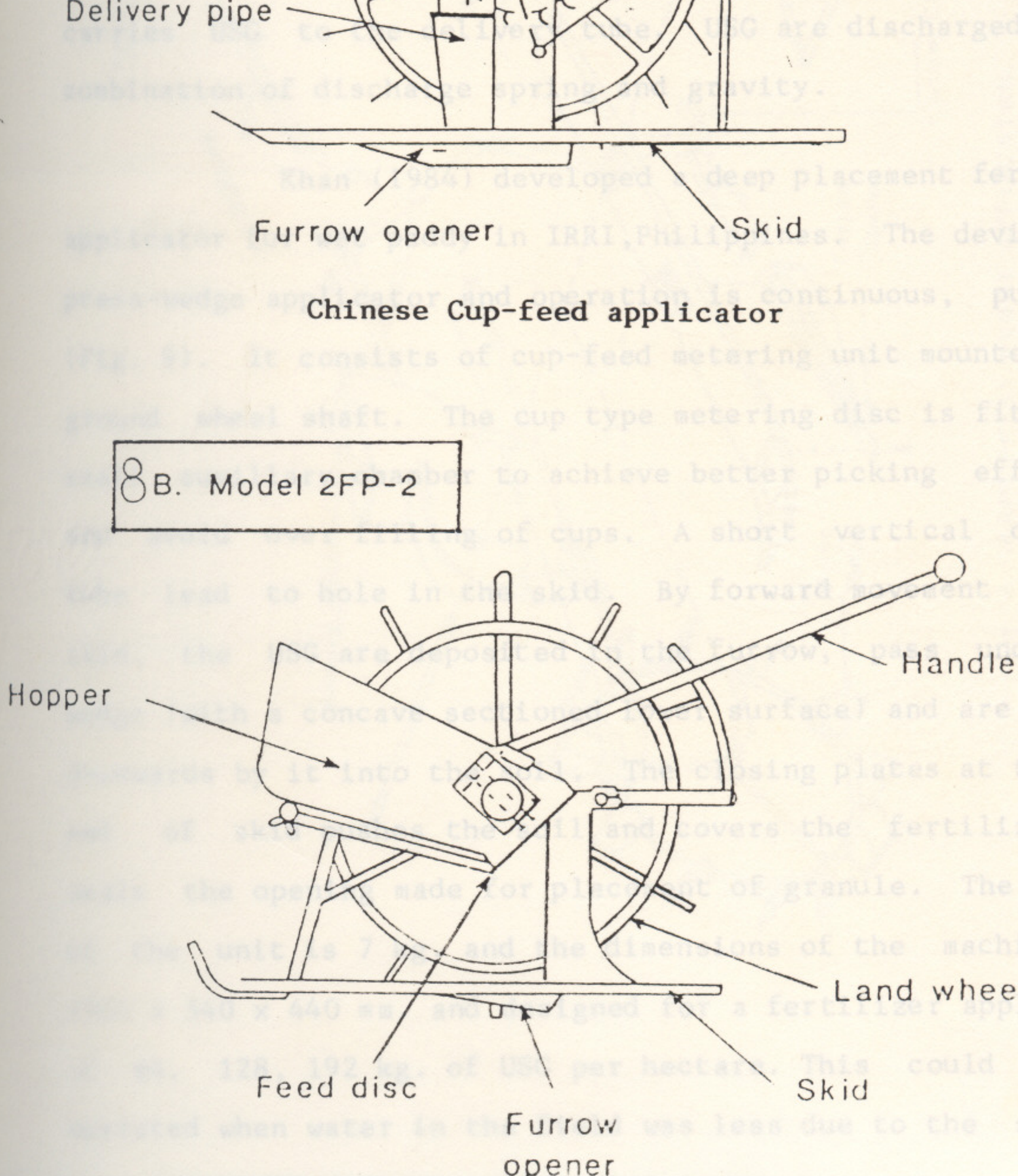
Liu (1984) developed small fertilizer applicators in Fujian acadamy of agricultural sciences (FAAS), China. The device was cup-feed (model 2 FP-1) applicator and operation is continuous and push-type (Fig.8a). It consists of a handle and land drive wheel with two fertilizer delivery units. Each unit has a hopper with feed wheel fitted with cups and mounted on the wheel shaft. The cups pick up one USG each, which is then dropped through a delivery tube and finally through an aperture in the skid into a furrow. The rear end of the skid seals the furrow. An agitator mounted on the shaft in each hopper prevents bridging.

8A. Model 2FP-1



Chinese Cup-feed applicator

8B. Model 2FP-2



Chinese disc feed applicator

Liu (1984) modified the same model 2 FP-1 except metering mechanism and developed a disc feed applicator (model 2 FP-2, fig.8b). The operation is continuous and push-type. A revolving disc placed in the bottom of the hopper is driven by the main shaft of the land wheel. The disc with holes carries USG to the delivery tube. USG are discharged by a combination of discharge spring and gravity.

Khan (1984) developed a deep placement fertilizer applicator for wet paddy in IRRI,Philippines. The device was press-wedge applicator and operation is continuous, push-type (Fig. 9). It consists of cup-feed metering unit mounted on a ground wheel shaft. The cup type metering disc is fitted in small auxillary chamber to achieve better picking efficiency and avoid over filling of cups. A short vertical delivery tube lead to hole in the skid. By forward movement of the skid, the USG are deposited in the furrow, pass under the wedge (with a concave sectioned lower surface) and are forced downwards by it into the soil. The closing plates at the tail end of skid pushes the soil and covers the fertilizer and seals the opening made for placement of granule. The weight of the unit is 7 kg. and the dimensions of the machine are 1900 x 540 x 440 mm. and designed for a fertilizer application of 64, 128, 192 kg. of USG per hectare. This could not be operated when water in the field was less due to the sticking

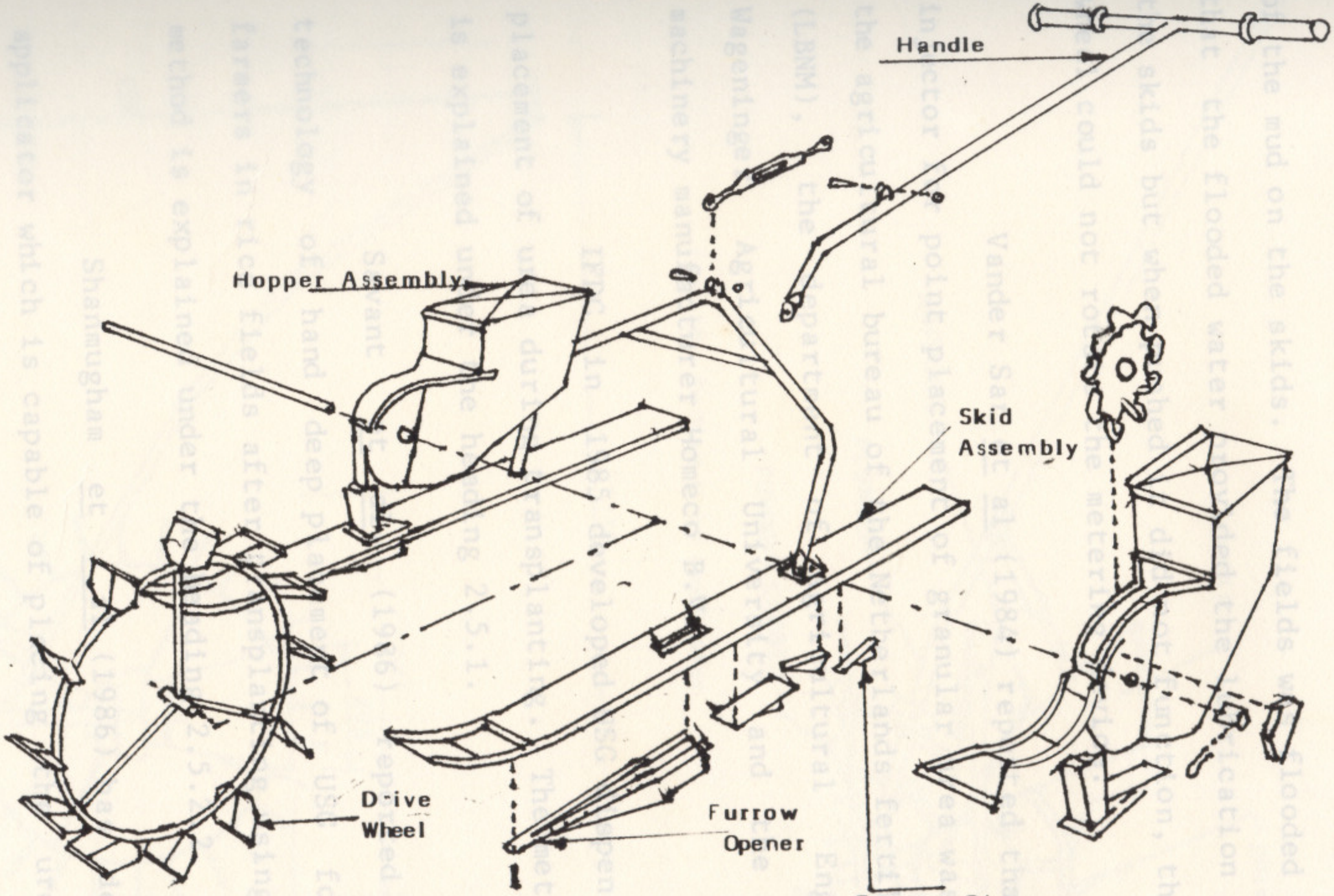


Fig. 9. IRRI'S PRESS WEDGE APPLICATOR.

of the mud on the skids. The fields was flooded with water so that the flooded water provided the lubrication action below the skids but when pushed it did not function, the small size wheel could not rotate the metering device.

Vander Sar et al (1984) reported that a pneumatic injector for point placement of granular urea was developed by the agricultural bureau of the Netherlands fertilizer industry (LBNM), the department of agricultural Engineering of Wageninger Agricultural University and the Dutch farm machinery manufacturer Homeco B.V.

IFDC in 1985 developed USG dispenser for hand placement of urea during transplanting. The method of working is explained under the heading 2.5.1.

Savant et al. (1986) reported an improved technology of hand deep placement of USG for small rice farmers in rice fields after transplanting using IFDC TG. The method is explained under the heading 2.5.2.2.

Shanmugham et al.(1986) has developed a PU applicator which is capable of placing the urea at a depth of 4.5 cm. below the soil surface. The modified PU applicator is shown in figure (10). The machine is manually operated, and push-type. The over all dimensions of the device was 1640 x 460 x 820 mm and

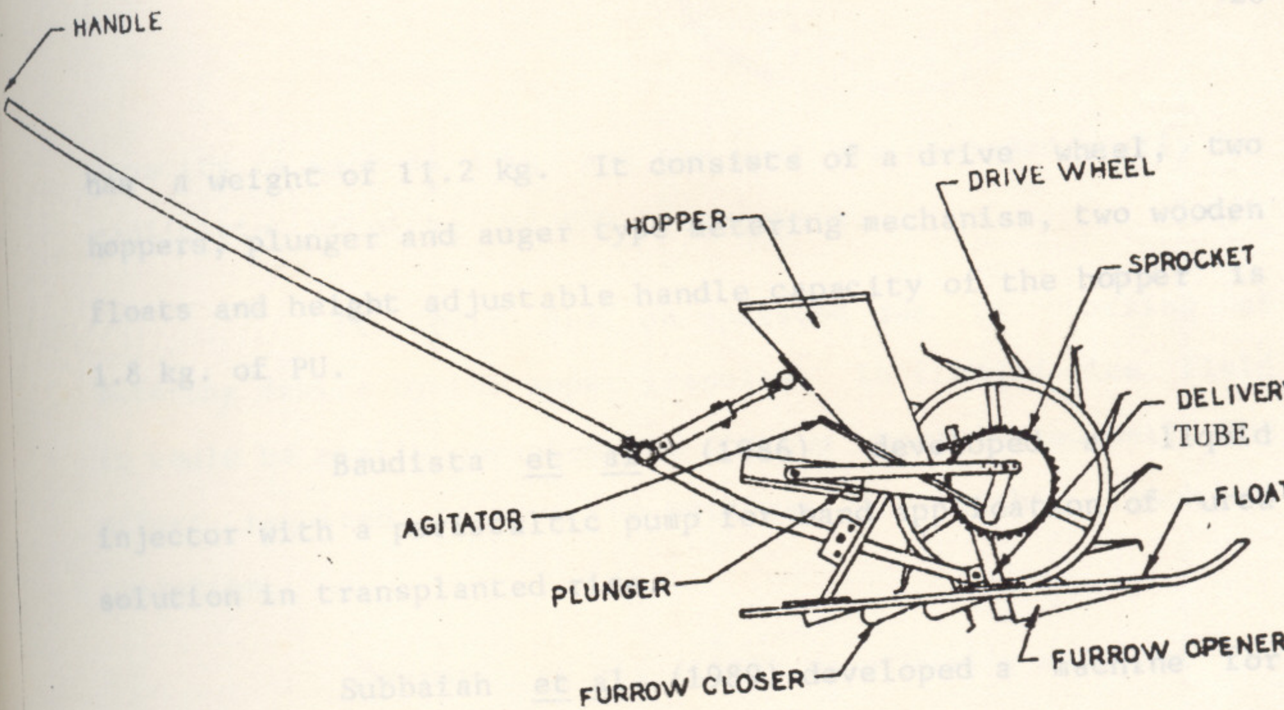


Fig. 10. Prilled Urea applicator

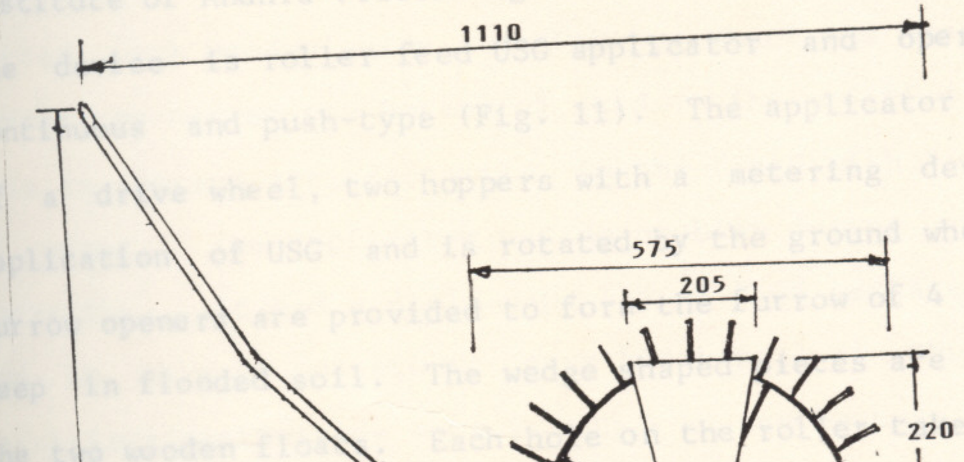


Fig. 11. USG applicator for paddy - APAU design.

has a weight of 11.2 kg. It consists of a drive wheel, two hoppers, plunger and auger type metering mechanism, two wooden floats and height adjustable handle capacity of the hopper is 1.8 kg. of PU.

Baudista et al. (1986) developed a liquid injector with a peristaltic pump for band application of urea solution in transplanted rice.

Subbaiah et al. (1989) developed a machine for the application of USG in rice fields at agricultural research Institute of Andhra Pradesh Agricultural University (A.P.A.U). The device is roller feed USG applicator and operation is continuous and push-type (Fig. 11). The applicator consists of a drive wheel, two hoppers with a metering devices for application of USG and is rotated by the ground wheel. Two furrow openers are provided to form the furrow of 4 to 5 cms. deep in flooded soil. The wedge shaped pieces are fixed on the two wooden floats. Each hole on the roller takes one USG and drops it into the furrow made by furrow openers. The USG are then covered with soil by the floats when the applicator is pushed. Weight of the unit is 12.5 kg. and dimensions are 1250 x 560 x 800 mm. A handle bar is provided to push the machine in the field during operation. The fertilizer hopper capacity is kept as 3 kg and the unit are designed mostly for application of 66 kg of USG per hectare.

It could not be operated due to chocking of metering device by the super granules. In flooded rice field it could be easily operated and the lug wheel worked well. The effort required to move the unit was also within reach of operation.

Devnani et al. (1989) developed a modified USG applicator in CIAE Bhopal. In CIAE model they modified the IRRI model to suit the local conditions. The IRRI model was fitted with wooden skids and APAU lug wheel and wedge shaped furrow opener at the bottom of skids. The modified unit was able to operate satisfactorily in the field with 5 to 10 cms of water. The applicator has no problem during the field operation. It had a field capacity of 0.06 hectare per hour and is able to operate in heavy black soil at Bhopal. The fertilizer application rate is 130.5 kg per hectare.

Savant et al. (1989) developed UB applicator for transplanted rice IFDC, USA.Fig.(12). The operation is non-continuous and pull-type. This is completely hand operated and is made of PVC pipe and is specially designed for deep placement of UB. It consists of two PVC plungers, two PVC delivery tubes, the handle, a conecting wooden frame and two

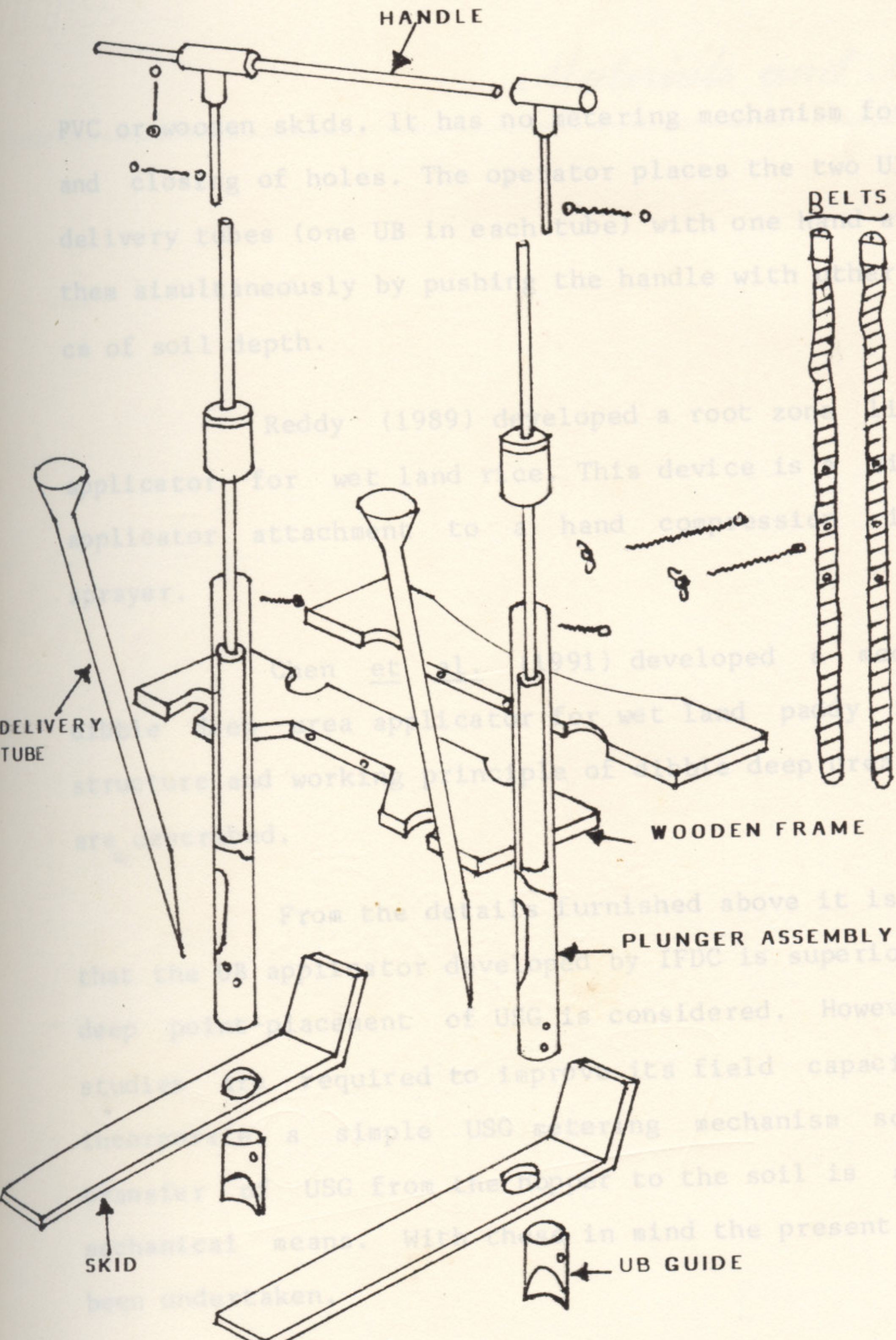


Fig. 12. UB APPLICATOR IFDC DESIGN

PVC or wooden skids. It has no metering mechanism for opening and closing of holes. The operator places the two UB in the delivery tubes (one UB in each tube) with one hand and inserts them simultaneously by pushing the handle with other to a 7-10 cm of soil depth.

Reddy (1989) developed a root zone liquid urea applicator for wet land rice. This device is a simple urea applicator attachment to a hand compression insecticide sprayer.

Chen et al. (1991) developed a mechanism of dibble deep urea applicator for wet land paddy field. The structure and working principle of dibble deep urea applicator are described.

From the details furnished above it is concluded that the UB applicator developed by IFDC is superior as far as deep point-placement of USG is considered. However further studies are required to improve its field capacity and to incorporate a simple USG metering mechanism so that the transfer of USG from the hopper to the soil is achieved by mechanical means. With these in mind the present study has been undertaken.

MATERIALS AND METHODS

The design details and selection of individual components of the USG applicator and experimental programme are presented in this chapter.

The functional requirements of the USG applicator are as given below:

(a) As per the Package of Practices of Kerala Agricultural University, spacing of paddy seedlings = 20x15 cm.

(b) As per the IFDC recommendations. number of USG per hole=1.

Rate of USG application= 32 to 80 kg per ha (application rate is one granule per four hills of paddy).

Depth of placement = 5-8 cm.

(c) As per the USG applicator developed by APAU, TNAU and CIAE.

The USG is applied in alternate rows.

Application rate=1 granule per 2 hills of paddy.

Row to row spacing of applicator- 40 cm.

Plant to plant spacing of applicator- 15 cm.

(d) Each unit of the applicator could be operated individually.

(e) The applicator could be operated in lined transplanted as well as conventionally transplanted fields.

(f) The implement should be able to operate in the field manually at a forward speed of 0.3 kmph.

(g) The number of rows and columns is two each for easy turning at headland and for more coverage of area.

(h) The number of components should be least for easy manoeuvrability and maintenance by the farmers.

(i) It should be of simple design and construction, so that it require minimum technical knowledge for operation and maintenance.

(j) The components could be fabricated and assembled locally with readily available materials from the local market.

(k) The whole operation could be done by one man.

(l) The weight of the implement should be less.

(m) The cost should be within the limit so that a small farmer can own a unit.

3.1. GENERAL LAY OUT AND DETAILS OF USG APPLICATOR

In order to achieve these functional requirements, a two-row, two-column manually operated applicator is developed. It consists of the following parts:

Plunger, delivery tube, main hopper, fertilizer tube, frame, covering mechanism, ground wheel, handle and metering mechanism. Details of the machine are shown in fig.13.

3.1.1. Plunger

The plunger is made of PVC material. The plunger pushes the USG, which comes from fertilizer tube to the required soil depth. The overall length of the plunger is 590 mm and has a diameter of 20 mm The top and bottom end of the plunger is fastened with M.S. rod and wooden rod of length 5 cm respectively. The bottom end of the plunger is slightly sloping outwards from the entry of fertilizer tube, in order to avoid mechanical damage.

In order to take compressive loads due to the presence of stubbles and stones in the field, the plunger is spring loaded. A PVC collar of diameter 26 mm and length 45 mm is fastened at the top of the plunger. It acts as a collar and provide seating for the spring. A PVC pipe of length 125

PLATE No.1. FRONT VIEW OF USG APPLICATOR.

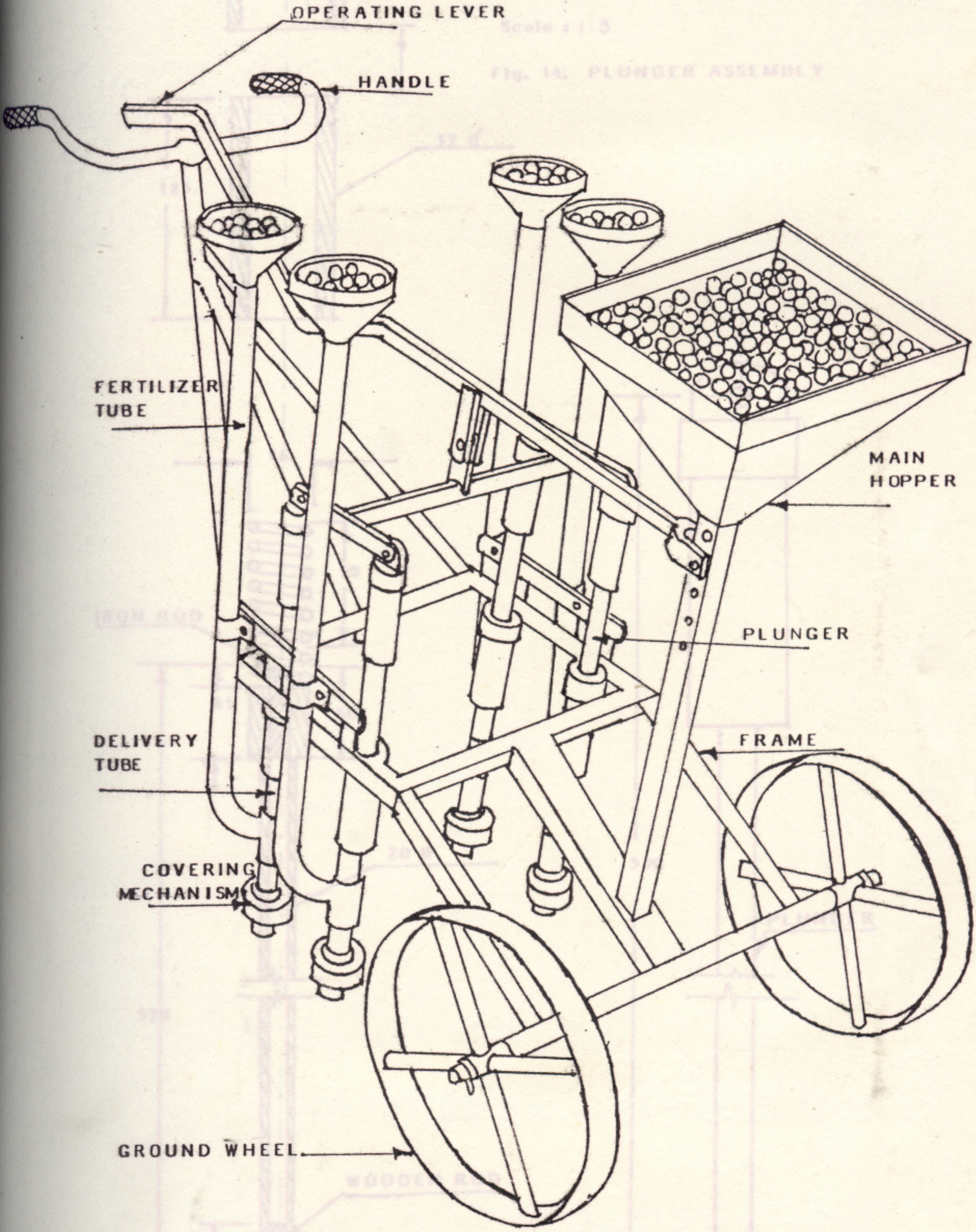


Fig. 13. Isometric view of USG applicator.

All dimensions in mm.

Scale : 1:3

Fig. 14. PLUNGER ASSEMBLY

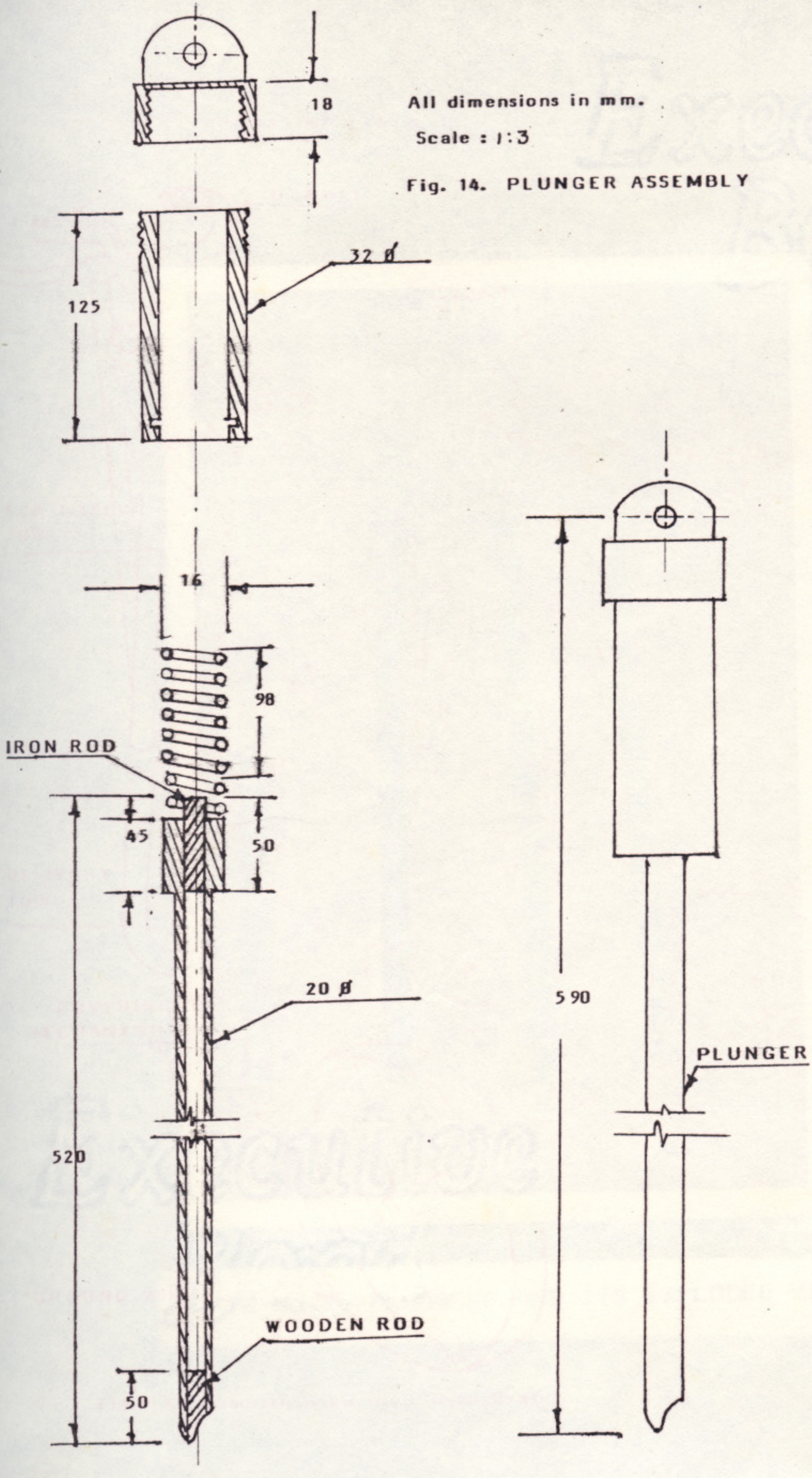


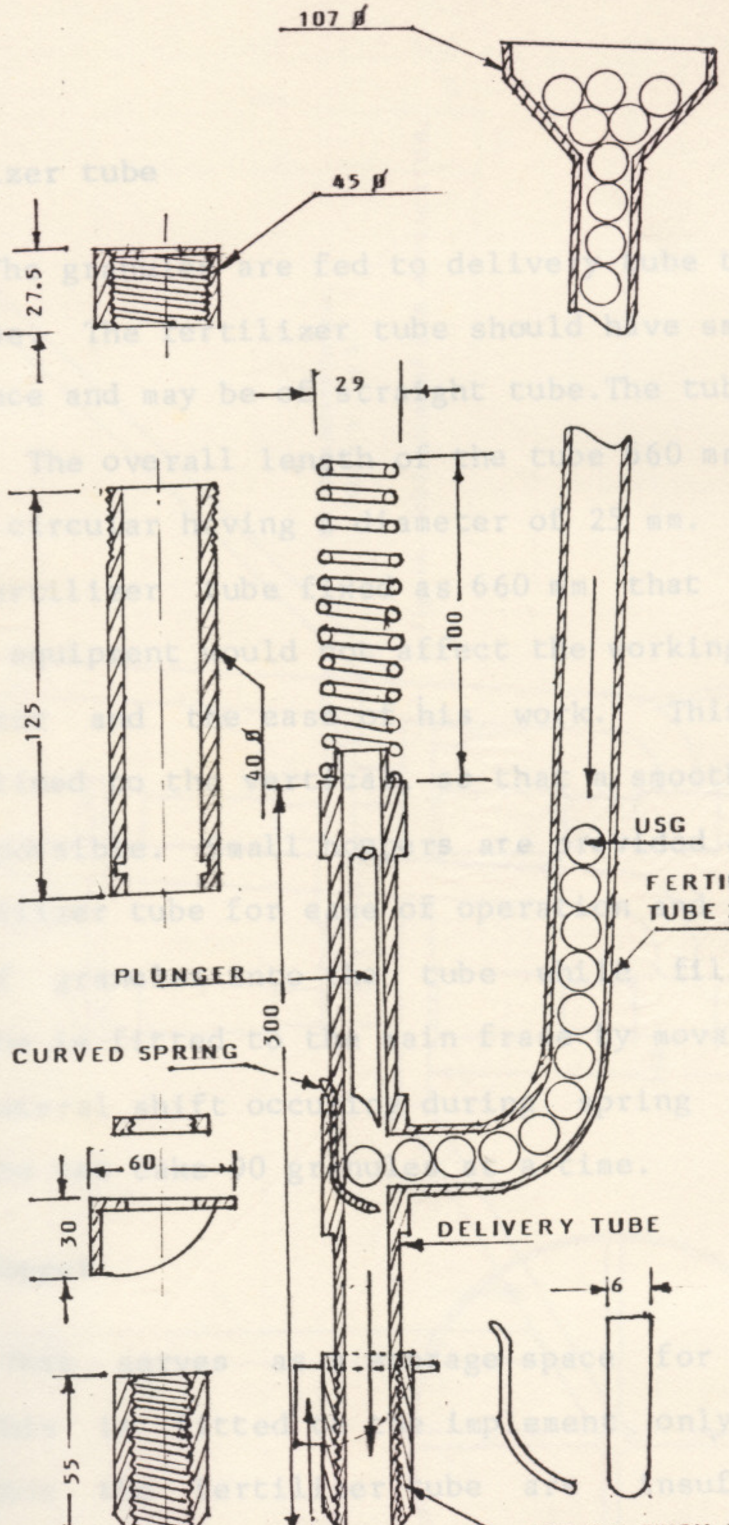
PLATE No.2. PLUNGERS AND ITS EXPLODED VIEW.

PLATE No.3. DELIVERY TUBE ASSEMBLY AND ITS EXPLODED VIEW.

mm and diameter 32 mm is used as a guide for the spring. The constructional features of plunger with spring loaded mechanism is shown in fig. 14.

3.1.2. Delivery tube

Delivery tube includes covering mechanism, nylon bush and metering mechanism (Fig.15). The material is same as that of the plunger and has a length 350 mm and diameter 25 mm. 60 mm of the delivery tube at bottom is threaded and a nylon bush of 55 mm is provided, in order to take soil thrust during dibbling. To maintain uniform depth of penetration a M.S. flat plate of 60 mm diameter is used as a stopper. This is kept at the top of the nylon bush. A M.S. flat strip of 30 mm is curved and welded on the stopper, which will act as a covering mechanism. The stopper with covering mechanism is fixed with nylon bush at the bottom and nylon nut provided at the top of it. The delivery tube is also spring loaded in a similar fashion as that of the plunger, so that each unit can be operated individually. A 20 mm diameter hole is provided at a height of 52.5 mm from the bottom of the tube for the entry of granules from the fertilizer tube. A vertical slot is provided just opposite to the above hole, where a curved spring is kept for metering the granules. This will help to control the flow of urea granules one by one.



all dimensions in mm. scale : 1:3

Fig. 15. DELIVERY TUBE ASSEMBLY

3.1.3. Fertilizer tube

The granules are fed to delivery tube through the fertilizer tube. The fertilizer tube should have smooth walls to reduce bounce and may be of straight tube.The tube is made of PVC pipe. The overall length of the tube 660 mm and the cross section circular having a diameter of 25 mm. The total length of fertilizer tube fixed as 660 mm that the total height of the equipment would not affect the working capacity of an operator and the ease of his work. This tube is slightly inclined to the vertical, so that a smooth flow of granules is possible. Small hoppers are provided at the top of each fertilizer tube for ease of operation and to ensure the entry of granules into the tube while filling. The fertilizer tube is fitted to the main frame by movable clamps due to the lateral shift occuring during spring loading.The fertilizer tube can take 90 granules at a time.

3.1.4. Main hopper

This serves as a storage space for fertilizer material. This is fitted to the implement only when the granules inside the fertilizer tube are insufficient to complete to and fro travel in the field. The material used is M.S. Sheet. The details of the main hopper is shown in fig.16 & 17.

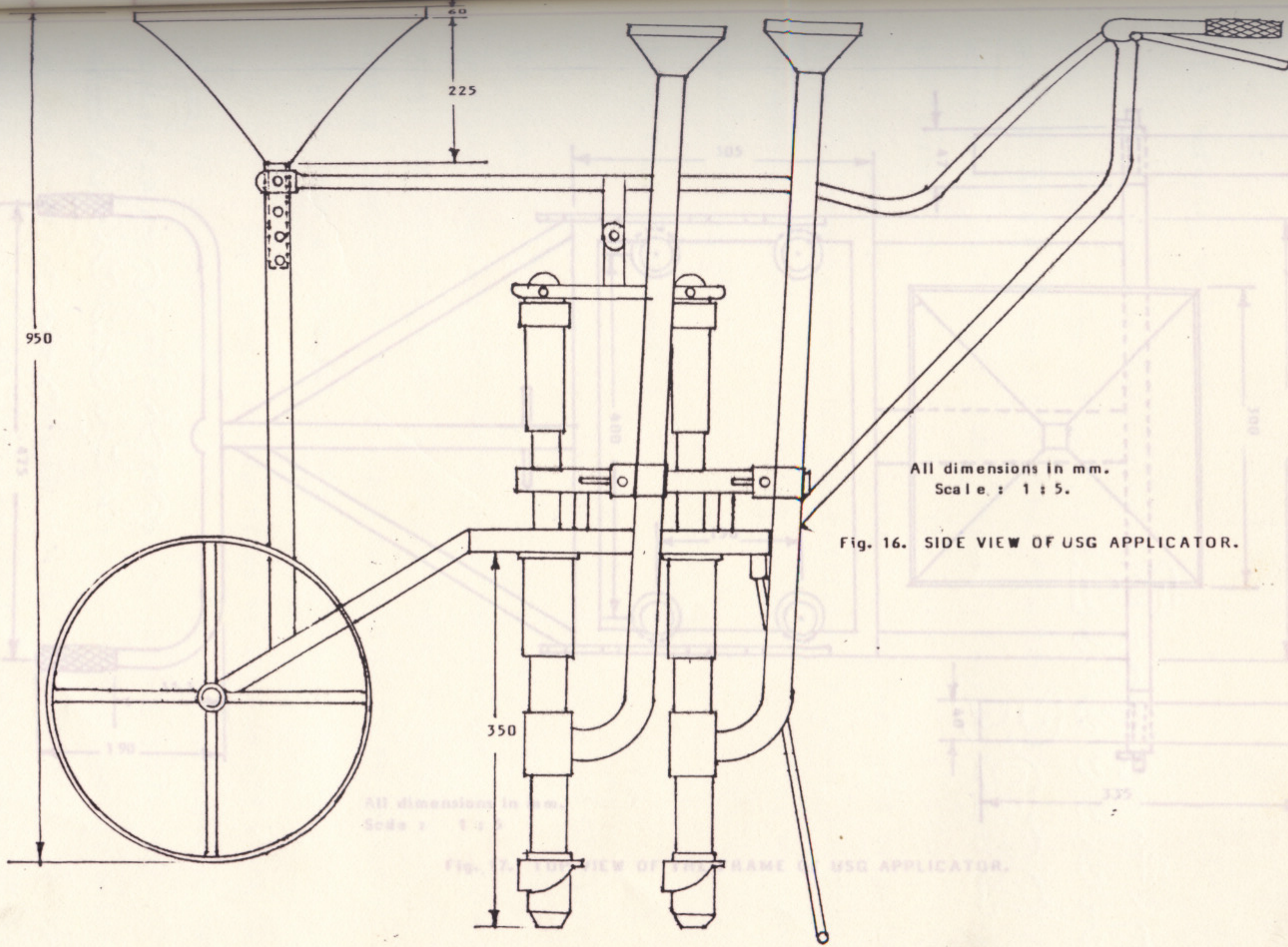
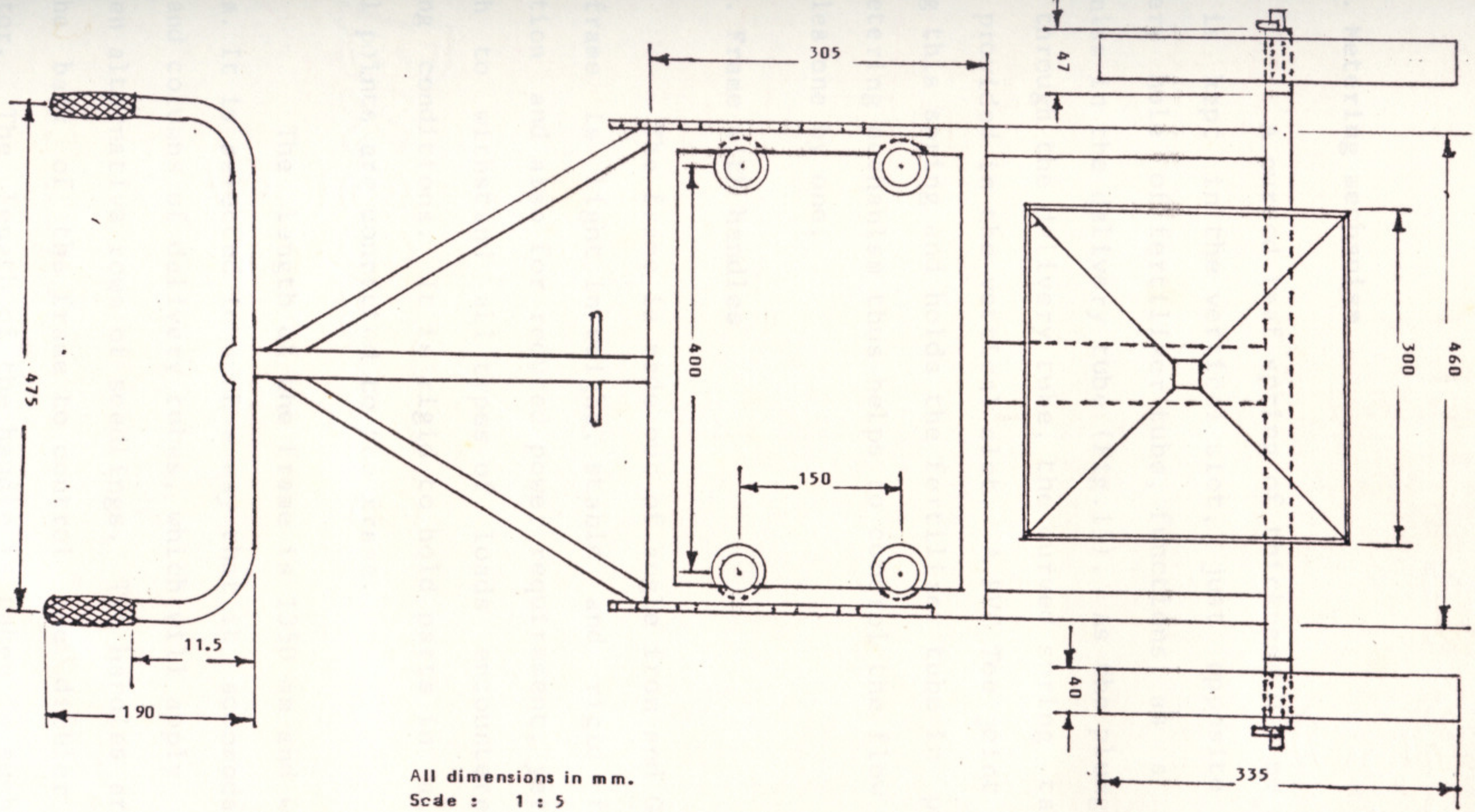


Fig. 16. SIDE VIEW OF USG APPLICATOR.



All dimensions in mm.
Scale : 1 : 5

Fig. 17. TOP VIEW OF THE FRAME OF USG APPLICATOR.

3.1.5. Metering mechanism

A curved leaf spring of thickness 0.5 mm and 6 mm wide is kept in the vertical slot, just opposite to the delivery hole of fertilizer tube, functions as a metering mechanism in the delivery tube (Fig.15). As the plunger moves down through the delivery tube, the curved spring takes the space provided in the vertical slot. A PVC Tee joint helps in fixing this spring and holds the fertilizer tube in position. The metering mechanism thus helps to control the flow of urea granules one by one.

3.1.6. Frame with handles

The frame is made out of angle iron and GI pipes. The frame is light in weight, stable and rigid for easy operation and also for reduced power requirement, yet strong enough to withstand all types of loads encountered under working conditions. It is rigid to hold parts in alignment, as all points are connected to the frame.

The length of the frame is 1350 mm and width is 40 mm. It is selected in such a way that it accomodated two rows and columns of delivery tubes, which will apply granules between alternative rows of seedlings. Two handles are welded to the back of the frame to control the dibbler by the operator. The length of the handle is taken in such a way

PLATE No.4. ISOMETRIC VIEW OF USG APPLICATOR.

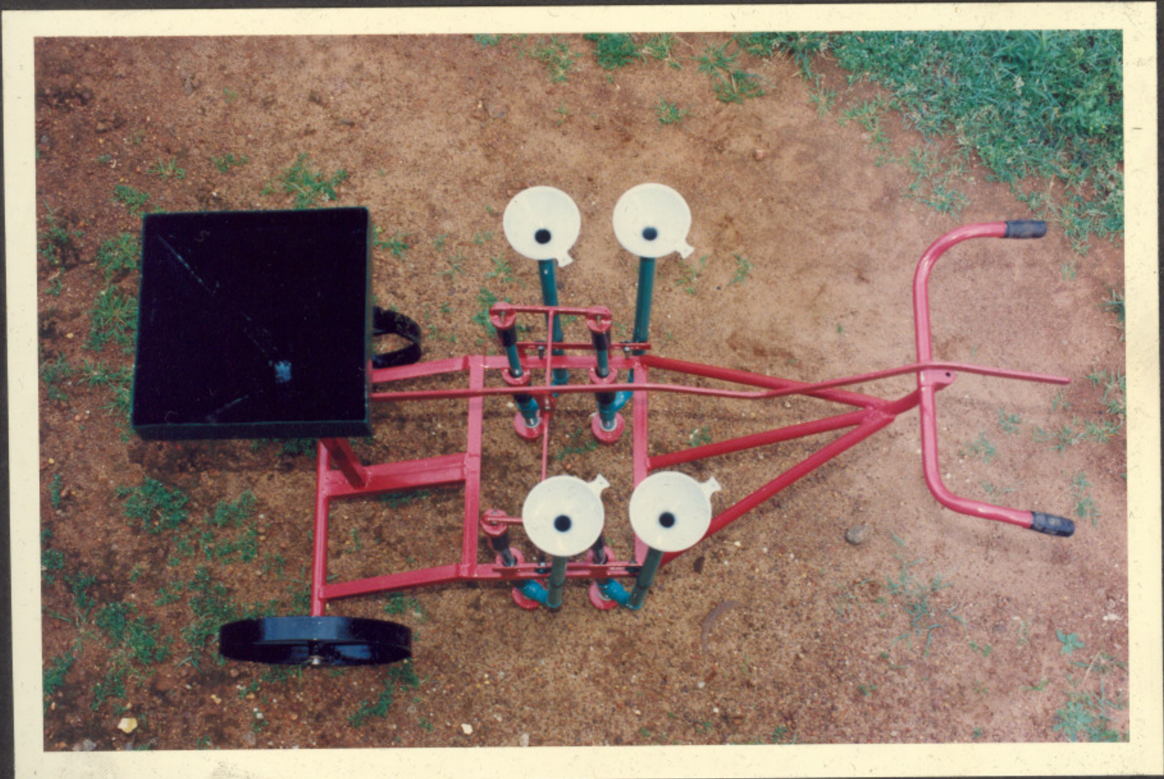
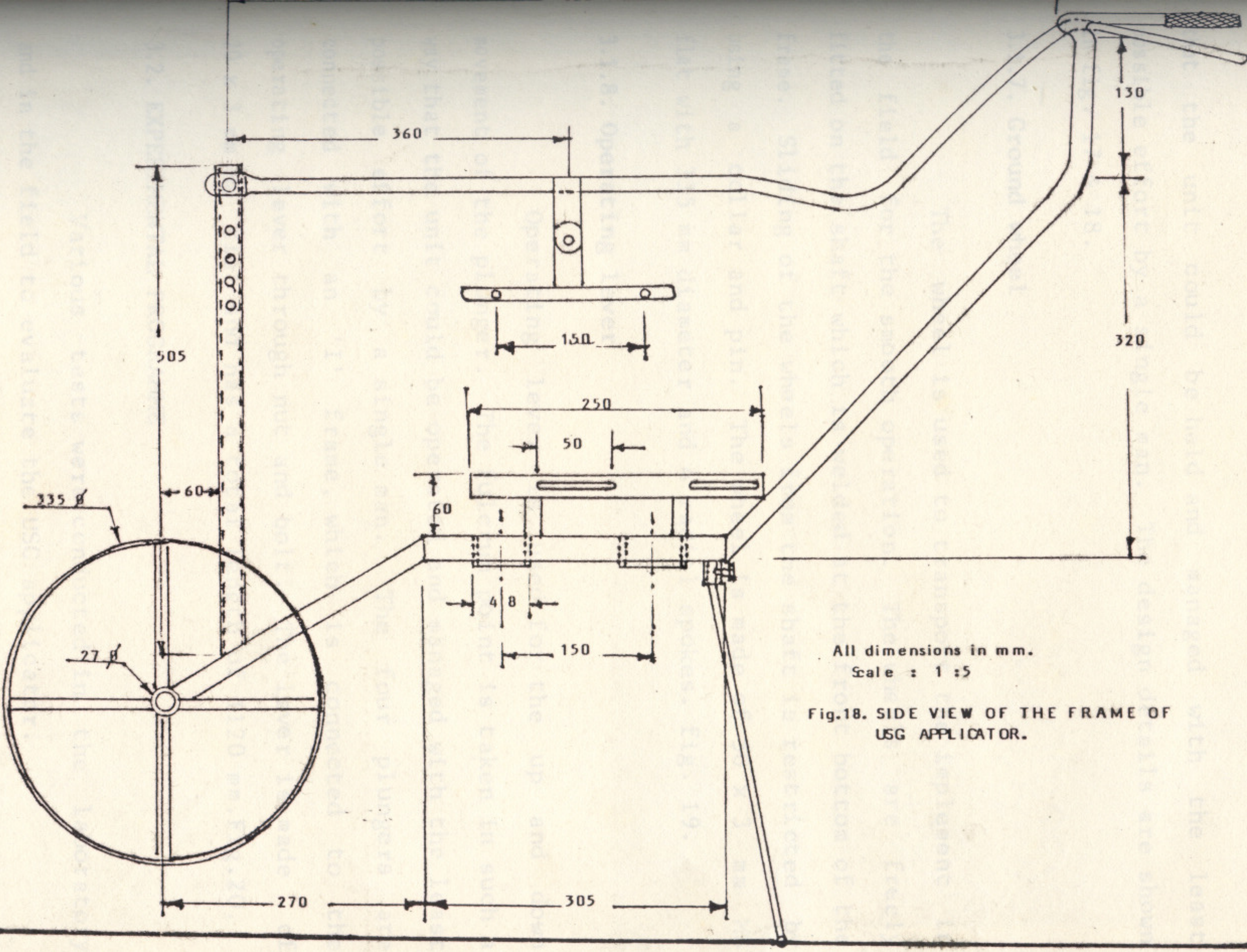


PLATE No.5. PLAN OF USG APPLICATORS



All dimensions in mm.
Scale : 1 :5

Fig.18. SIDE VIEW OF THE FRAME OF USG APPLICATOR.

that the unit could be held and managed with the least possible effort by a single man. The design details are shown in fig. 17 & 18.

3.1.7. Ground wheel

The wheel is used to transport the implement in the field for the smooth operation. The wheels are freely fitted on the shaft which is welded at the front bottom of the frame. Sliding of the wheels from the shaft is restricted by using a collar and pin. The wheel is made of 50 x 3 mm MS flat with 335 mm diameter and 4 radial spokes. fig. 19.

3.1.8. Operating lever

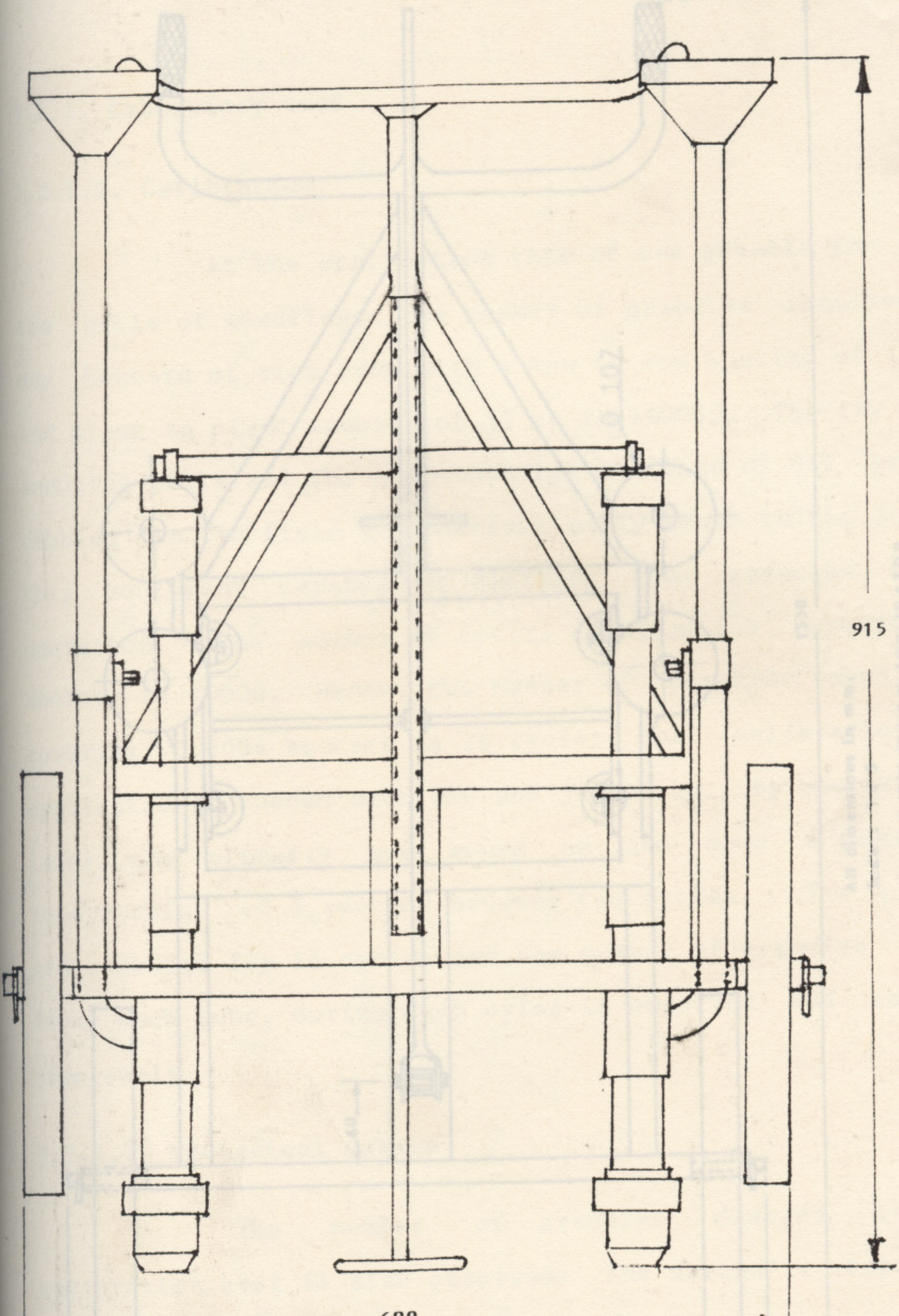
Operating lever is used for the up and down movement of the plunger. The fulcrum point is taken in such a way that the unit could be operated and managed with the least possible effort by a single man. The four plungers are connected with an 'I' frame, which is connected to the operating lever through nut and bolt. The lever is made of 20 x 3 mm MS flat and has a total length of 1120 mm.Fig.20.

3.2. EXPERIMENTAL PROGRAMME

Various tests were conducted in the laboratory and in the field to evaluate the USG applicator.

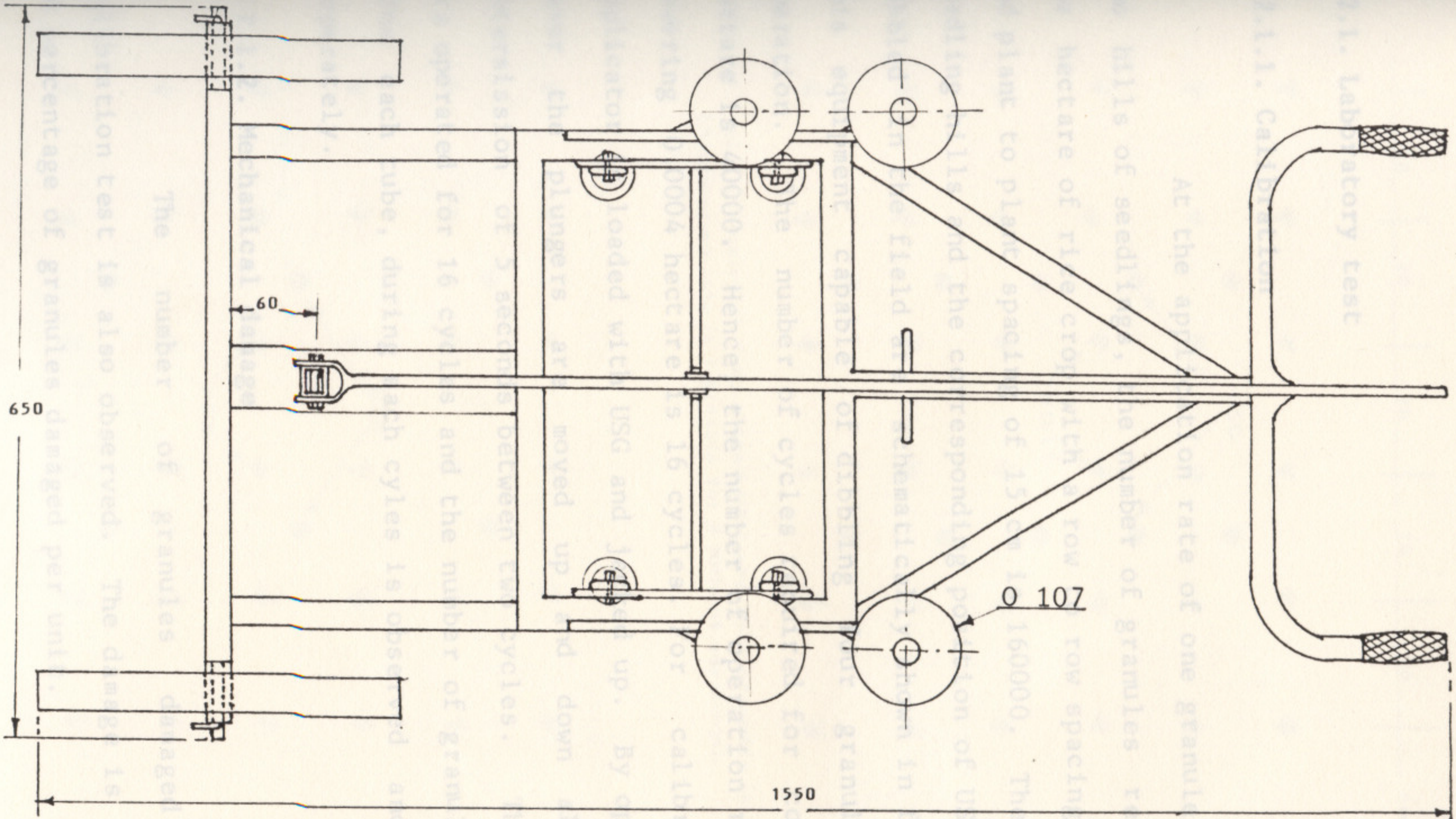
PLATE No.6(a). SIDE VIEW OF USG APPLICATOR

PLATE No.6(b). OPERATIG LEVER IN WORKING CONDITION.



All dimensions in mm.
Scale : 1 : 5

Fig. 19. FRONG VIEW OF USG APPLICATOR.



All dimensions in mm.
Scale : 1 : 5

Fig. 20. TOP VIEW OF USG APPLICATOR.

.2.1. Laboratory test

.2.1.1. Calibration

At the application rate of one granule for every wo hills of seedlings, the number of granules required for ne hectare of rice crop with a row to row spacing of 20 cm nd plant to plant spacing of 15 cm is 160000. The lay out of eedling hills and the corresponding position of USG granules ibbled in the field are schematically shown in fig.21. For his equipment capable of dibbling four granules in one peration. The number of cycles required for covering one ectare is 40000. Hence, the number of operation required for overing 0.0004 hectare is 16 cycles. For calibration the pplicator is loaded with USG and jacked up. By operating the ever the plungers are moved up and down allowing an ntermission of 5 seconds between two cycles. The plungers re operated for 16 cycles and the number of granules dropped rom each tube, during each cyles is observed and collected eperately.

.2.1.2. Mechanical damage

The number of granules damaged in each alibration test is also observed. The damage is represented n percentage of granules damaged per unit.

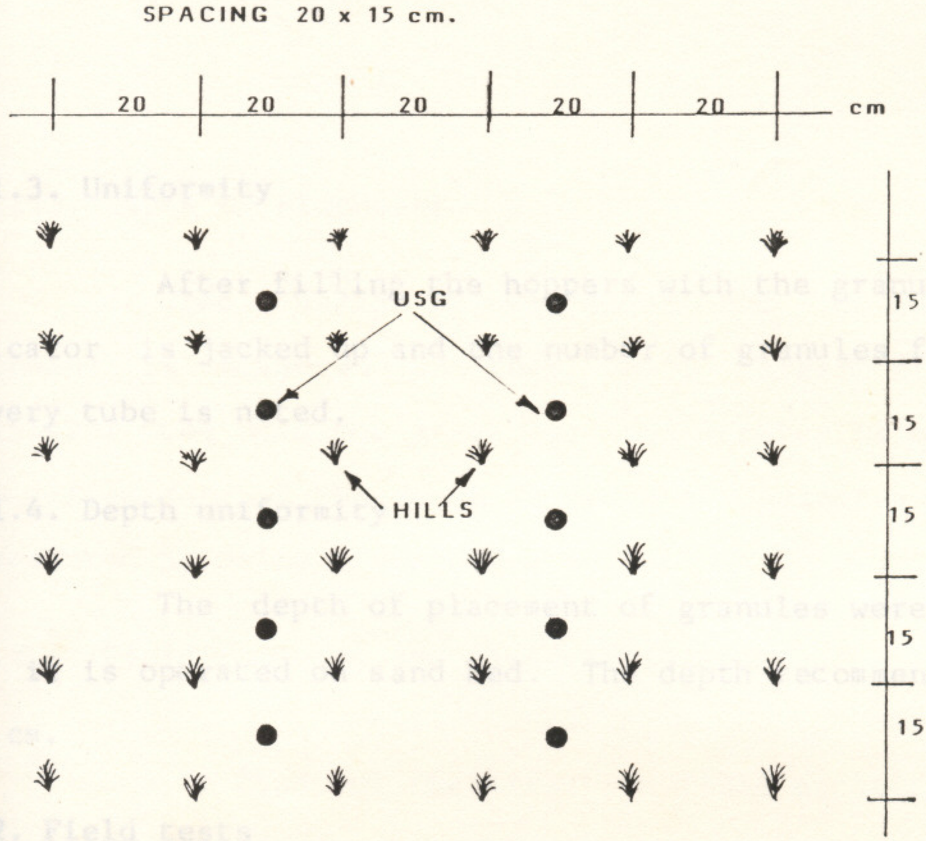


Fig. 21. (a). Geometry of deep placed USG and Hills of paddy in soil. (Application rate is 1 granule for 2 hills of seedlings).

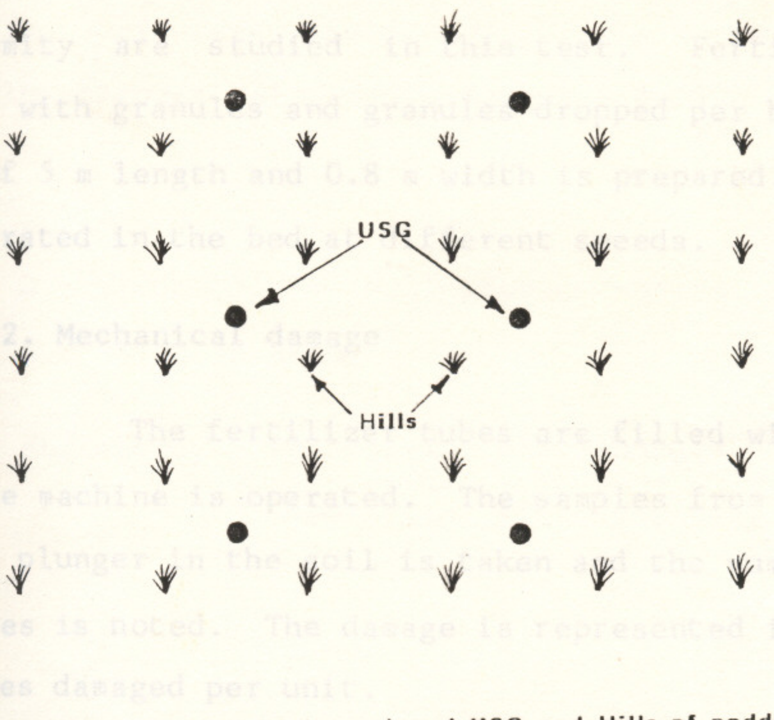


Fig. 21. (b). Geometry of deep placed USG and Hills of paddy in soil. (Application rate is 1 granule for 4 hills of seedlings).

3.2.1.3. Uniformity

After filling the hoppers with the granules, the applicator is jacked up and the number of granules from each delivery tube is noted.

3.3.1.4. Depth uniformity

The depth of placement of granules were checked when it is operated on sand bed. The depth recommended is 5 to 8 cm.

3.2.2. Field tests

3.2.2.1. Uniformity

Fertilizer distribution pattern and the uniformity are studied in this test. Fertilizer tube is filled with granules and granules dropped per hill is noted. A bed of 5 m length and 0.8 m width is prepared. The implement is operated in the bed at different speeds.

3.2.2.2. Mechanical damage

The fertilizer tubes are filled with the granules and the machine is operated. The samples from each hole made by the plunger in the soil is taken and the number of damaged granules is noted. The damage is represented in persentage of granules damaged per unit.

3.2.2.3. Depth of placement

The depth of placement and uniformity in placement is measured in this test. After filling the fertilizer tube with the granules, the dibbler is operated to a specified depth. The depth at which its granules are placed is measured by using a measuring scale.

3.2.2.4. Field capacity and field efficiency

To find out the effective field capacity, a plot size of 10 mx 0.8 m is selected and granules are dibbled by the equipment. The time taken to cover the area is also noted.

The effective field capacity = Area covered/Actual time

The theoritical field capacity = WS/10

where,

W - Width of USG applicator in meters

S - Speed in kmph.

$$\text{Field efficiency} = \frac{\text{Effective field capacity}}{\text{Theoratical field capacity}} \times 100$$

RESULTS AND DISCUSSION

The results of the laboratory and field studies and observation based on these are presented in this chapter.

4.1. LABORATORY TEST

The laboratory test are conducted as explained under 3.2.1.

4.1.1. Calibration

The results of the test conducted for calibration is given in table 1. The average granule rate obtained is 155800 granules per hectare. ie., 155.8 kg per hectare. When the application rate is one granule for every two hills of seedlings. If the application rate is one granule for four hills of seedlings, the application rate would be 77900 granules per hectare ie., 77.9 kg/ha. The recommended fertilizer rate for USG applicator by IFDC is 32 to 80 kg/ha., which is at the rate of one granule for every four hills of seedlings. The results shows that the fertilizer rate obtained is within the recommended range.

4.1.2. Mechanical damage

The results of the test to assess mechanical

LABORATORY TEST

Table 1.

Test : Calibration.
Rate setting - 1 granule/unit
Required granule rate - 32 to 80 kg N /ha.
Average weight of each granule - 1.0 g

Test No.	Area covered			Initial no. of granules	No. of granules after Operation	Difference in no.	Graanule rate [No.'s /ha]	Granule rate [kg/ha]
	Width (m)	Length (m)	Area (m)					
1	0.8	5	4.0	80	14	66	165000	165.0
2	0.8	5	4.0	80	17	63	157500	157.5
3	0.8	5	4.0	80	15	65	162500	162.5
4	0.8	5	4.0	80	25	55	137500	137.5
5	0.8	5	4.0	80	16	64	160000	160.0
6	0.8	5	4.0	80	19	61	152500	152.5
Average granule rate [kg/ha]								155.8

LABORATORY TEST

Table 2.

Experiment - Mechanical damage

Rate setting - 1 granule/unit

Sl. No.	1	2	3	4	Average no. of granules damaged/unit (%)
1	0	0	0	0	0
2	1	0	0	0	25
3	1	0	0	0	25
4	0	0	0	0	0
5	1	1	0	0	50
6	0	0	0	0	0
7	0	0	0	0	0
9	0	0	0	0	0
10	0	0	0	0	0
11	0	0	0	0	0
12	0	0	0	0	0
13	0	0	0	0	0
14	0	0	0	0	0
15	0	0	0	0	0
16	1	0	0	0	25
Average no. of granules damaged/unit (%)	25	6.25	0.0	0.0	7.8

damage is presented in table 2. The number of granules damaged is at the average rate of 7.8 per cent per unit. This higher percentage in the number of granules damaged is due to the improper positioning of the granules in the metering zone.

4.1.3. Uniformity test

The number of granules fallen from each delivery tube for each stroke is presented in table 3. The average number of granules fallen per cycle is one per unit, which is the recommended rate.

4.1.4. Depth uniformity

The results of the test conducted for uniformity of placement depth is shown in table 4. The average depth of placement is 5.5 cm. The recommended depth is 5 to 8 cm. The results shows that the depth of placement obtained is well within the recommended range.

4.2. FIELD TEST

The results of the field test are discussed.

4.2.1. Uniformity test

The number of granules fallen per hill for different speeds of operation conducted in the field are recorded in tables 5, 6 and 7. It is found that the average

LABORATORY TEST

Table 3.

Experiment - Uniformity test
Rate setting - 1 granule/unit

Sl. No.	1	2	3	4	Average no. of granules/unit
1	1	1	1	1	1
2	1	1	1	1	1
3	1	1	1	1	1
4	1	1	1	1	1
5	1	1	1	1	1
6	1	1	1	1	1
7	1	1	2	1	1.25
8	1	1	1	1	1
9	1	1	1	1	1
10	1	1	1	1	1
11	1	1	1	1	1
12	1	1	1	1	1
13	1	1	1	1	1
14	1	1	1	1	1
15	1	1	0	1	0.75
16	1	1	1	1	1
Average no. of granules /unit	1	1	1	1	1

LABORATORY TEST

SAND BED TEST

Table 4.

Experiment - Depth uniformity
Rate setting - 1 granule/unit

Sl. No.	1	2	3	4	Average depth (cm.)
1	6.0	6.0	5.5	5.5	5.75
2	4.5	6.0	6.0	6.0	5.63
3	4.5	4.5	5.0	4.5	4.63
4	4.5	5.5	6.0	5.0	5.25
5	6.5	5.0	7.5	5.5	6.13
6	4.5	6.0	6.5	5.5	5.63
7	5.5	5.5	5.5	5.5	5.50
8	5.0	5.5	5.5	6.0	5.50
9	6.0	5.0	6.5	6.0	5.88
10	4.5	6.0	6.5	5.5	5.88
11	6.5	5.5	6.5	6.0	6.13
12	5.5	5.0	6.5	5.0	5.50
13	5.0	4.5	6.0	4.5	5.00
14	5.0	5.0	6.0	5.0	5.25
15	5.0	5.5	5.5	5.5	5.38
16	5.5	5.0	6.0	5.0	5.38
Average depth (cm)	5.3	5.3	6.1	5.4	5.52

Table 5.

Experiment - Uniformity test
Field Condition - standing water
Speed - 0.17 kmph.
Rate setting - 1 granule/unit

Width of bed - 0.8 m
Length of bed - 10 m
Time taken - 210 Sec

Sl. No.	1	2	3	4	Average no. of granules/unit
1	1	1	1	1	1
2	1	1	1	1	1
3	1	1	1	1	1
4	1	1	1	1	1
5	1	1	1	1	1
6	1	0	1	1	0.75
7	1	1	1	0	0.75
8	0	1	1	1	0.75
9	1	1	0	1	0.75
10	1	1	1	0	0.75
10	0	1	1	1	0.75
12	1	1	0	1	0.75
13	1	0	1	1	0.75
14	1	1	1	1	1
15	1	1	1	0	0.75
16	1	1	1	1	1
Average no. of granules /unit	0.875	0.875	0.875	0.813	0.859

Table 6.

Experiment - Uniformity test
Field Condition - standing water
Speed - 0.225 kmph.
Rate setting - 1 granule/unit

Width of bed - 0.8 m
Length of bed - 10 m
Time taken - 160 Sec

Sl. No.	1	2	3	4	Average no. of granules/unit
1	1	1	1	0	0.75
2	2	1	1	1	1.25
3	1	1	1	1	1
4	1	1	1	1	1
5	2	1	1	1	1.25
6	1	1	1	1	1
7	1	0	1	1	0.75
8	1	2	2	1	1.5
9	1	1	1	1	1
10	1	1	1	1	1
11	1	1	1	1	1
12	1	1	1	1	1
13	1	1	1	1	1
14	1	1	1	1	1
15	1	1	0	1	0.75
16	1	1	1	1	1
Average no. of granules /unit	1.125	1	1	0.938	1.016

Table 7.

Experiment - Uniformity test
Field Condition - Absence of standing water
Speed - 0.3 kmph
Rate setting - 1 granule/unit

Width of bed - 0.8 m
Length of bed - 10 m
Time taken - 120 Sec

Sl. No.	1	2	3	4	Average no. of granules/unit
1	1	1	1	1	1
2	1	1	1	1	1
3	1	1	1	1	1
4	1	1	1	1	1
5	1	1	1	1	1
6	1	1	1	1	1
7	1	1	1	1	1
8	1	1	1	1	1
9	1	1	1	1	1
11	1	1	1	1	1
11	1	1	1	1	1
12	1	1	1	1	1
13	1	1	1	1	1
14	1	1	1	1	1
15	1	1	1	1	1
16	0	1	1	1	0.75
Average no. of granules /unit	0.938	1	1	1	0.984

number of granules fallen per hill is 0.95 which is close to the recommended rate by IFDC. The missing hills are due to the irregular flow of USG into metering mechanism caused by the inadequate inclination to the bottom of the fertilizer tube.

4.2.2. Mechanical damage

The results of the test conducted for assessment of mechanical damage at different speeds in the field are given in tables 8, 9 and 10. The average percentage of the number of granules damaged is 5.73 per cent per unit.

4.2.3. Depth of placement

The results of the test conducted in the field for evaluating uniformity in placement depth at different speeds are shown in table 11, 12 and 13. The average depth of placement is 5.98 cm. The result shows that the average depth of placement is within the recommended range of 5 to 8 cm.

4.2.4. Field capacity and field efficiency

The theoratical field capacity at 0.17 kmph., 0.225 kmph., 0.30 kmph. are 0.0317 hectare per hour., 0.018 hectare per hour. and 0.024 hectare per hour. respectively. The effective field capacity obtained at these speeds are

Table 8.

Experiment - Mechanical damage
Field Condition - standing water
Speed - 0.17 kmph
Rate setting - 1 granule/unit

Width of bed - 0.8 m
Length of bed - 10 m
Time taken - 210 Sec

Sl. No.	1	2	3	4	Average no. of granules damaged/unit (%)
1	0	0	0	0	0
2	1	0	0	0	25
3	0	0	0	0	0
4	0	0	0	0	0
5	0	0	0	0	0
6	0	0	0	0	0
7	0	0	0	0	0
8	0	0	0	0	0
9	1	1	0	0	50
10	0	0	0	0	0
11	0	0	0	0	0
12	0	0	0	0	0
13	0	0	0	0	0
14	0	0	1	0	25
15	0	0	0	0	0
16	0	0	0	0	0
Average no. of granules damaged/unit (%)	12.5	6.25	6.25	0.0	6.25

Table 9.

Experiment - Mechanical damage
Field Condition - standing water
Speed - 0.225 km/hr.
Rate setting - 1 granule/unit

Width of bed - 0.8 m
Length of bed - 10 m
Time taken - 160 S

Sl. No.	1	2	3	4	Average no. of granules damaged/unit (%)
1	0	0	0	0	0
2	0	0	1	0	25
3	0	0	0	0	0
4	0	0	0	0	0
5	0	0	0	0	0
6	1	0	0	0	25
7	1	0	0	0	25
8	1	0	0	0	25
9	0	0	0	0	0
10	0	0	0	0	0
11	0	0	0	0	0
12	0	0	0	0	0
13	0	0	0	0	0
14	0	0	0	0	0
15	0	0	0	0	0
16	0	0	0	0	0
Average no. of granules damaged/unit (%)	18.75	0.0	6.25	0.0	6.25

FIELD TEST

Table 10.

Experiment - Mechanical damage
Field Condition - standing water
Speed - 0.300 kmph.
Rate setting - 1 granule/unit

Width of bed - 0.8 m
Length of bed - 10 m
Time taken - 120 Sec

Sl. No.	1	2	3	4	Average no. of granules damaged/unit (%)
1	0	0	0	0	0
2	0	0	0	0	0
3	0	0	0	0	0
4	0	0	0	0	0
5	0	0	0	0	0
6	0	0	0	0	0
7	0	0	0	0	0
9	1	0	0	0	25
10	0	0	0	0	0
11	0	0	0	0	0
12	0	0	0	0	0
13	0	0	0	0	0
14	0	0	1	0	25
15	0	0	1	0	25
16	0	0	0	0	0
Average no. of granules damaged/unit (%)	6.25	0.0	12.5	0.0	4.69

Table 11.

Experiment - Depth uniformity
Field Condition - Standing water
Speed - 0.17 kmph
Rate setting - 1 granule/unit

Width of bed - 0.8 m
Length of bed - 10 m
Time taken - 210 Sec

Sl. No.	1	2	3	4	Average depth (cm)
1	5.0	6.0	6.0	6.0	5.8
2	5.5	6.5	6.5	5.0	5.9
3	7.5	4.5	7.0	5.5	6.1
4	7.0	7.0	7.5	7.5	7.3
5	6.5	7.0	6.5	7.0	6.8
6	8.0	6.0	7.0	7.0	7.0
7	8.0	5.5	7.0	7.0	6.9
8	7.0	4.5	6.0	8.0	6.4
9	7.0	7.0	5.5	6.0	6.4
10	6.5	7.0	6.0	6.5	6.5
11	6.0	7.0	7.0	7.0	6.8
12	5.0	6.0	7.0	6.5	6.1
13	5.0	5.5	7.5	6.0	6.0
14	7.5	6.5	6.5	6.0	6.6
15	6.0	6.0	7.0	5.5	6.1
16	5.5	6.0	6.5	6.5	6.1
Average depth (cm)	6.4	6.1	6.7	6.4	6.4

Table 12.

Experiment - Depth uniformity
Field Condition - Standing water
Speed - 0.225 kmph
Rate setting - 1 granule/unit

Width of bed - 0.8 m
Length of bed - 10 m
Time taken - 160 Sec

Sl. No.	1	2	3	4	Average depth (cm.)
1	6.0	6.5	7.0	6.0	6.4
2	5.5	5.5	6.5	6.0	5.9
3	5	5.0	6.0	5.5	5.4
4	6.5	5.0	6.0	5.0	5.6
5	6.0	6.5	5.5	7.0	6.3
6	6.0	6.0	6.0	5.5	5.9
7	5.5	6.0	5.0	5.0	5.4
8	5.0	7.0	5.5	6.0	5.9
9	6.5	5.5	5.5	6.0	5.9
10	6.0	6.0	6.0	6.5	6.1
11	6.0	5.0	6.5	5.5	5.8
12	5.5	6.5	6.0	5.0	5.8
13	5.0	6.0	6.0	6.0	5.8
14	6.5	6.0	6.5	6.0	6.3
15	6.0	5.0	6.0	5.5	5.6
16	5.5	5.5	6.5	5.0	5.6
Average depth (cm)	5.8	5.8	6.0	5.7	5.9

Table 13.

Experiment - Depth uniformity
Field Condition - Absence of standing water
Speed - 0.3 kmph
Rate setting - 1 granule/unit

Width of bed - 0.8 m
Length of bed - 10 m
Time taken - 120 Sec

Sl. No.	1	2	3	4	Average depth (cm)
1	6.0	4.5	5.0	4.5	5.0
2	5.5	5.5	6.0	4.5	5.4
3	4.0	6.0	4.0	5.0	4.8
4	5.0	5.0	5.0	3.5	4.6
5	4.0	5.0	5.0	3.5	4.7
6	3.5	5.0	5.0	5.0	4.6
7	6.0	7.0	7.0	5.0	6.3
8	3.5	7.0	6.5	5.0	5.5
9	5.0	6.5	6.5	5.0	5.8
10	5.5	6.0	6.5	5.5	5.9
11	5.5	6.5	5.0	6.0	5.8
12	5.5	7.0	6.5	6.0	6.3
13	6.0	7.0	7.5	5.5	6.5
14	4.0	7.0	6.0	6.5	5.9
15	6.0	7.5	6.5	7.0	6.8
16	5.5	6.5	7	6.5	6.4
Average depth (cm)	5.0	6.2	5.9	5.3	5.6

0.0129 hectare per hour, 0.0167 hectare per hour and 0.0218 hectare per hour respectively. Average field efficiency obtained is 90.63 per cent. The results are shown in table 14. The low field capacity is because the application rate is one granule per two hills of seedlings instead of four hills of seedlings.

4.2.5. Economic analysis

The calculation of the operating cost of the USG applicator is given in appendix 1. The fabrication cost of the applicator including cost of material is Rs.800/- and operating cost is obtained as Rs.16/- per hour. The area covered per hour by the applicator is 0.017 hectare. The average labour requirement is 59 man hours per hectare. Therefore, the cost of applying granules in one hectare. of land is Rs.935/-. By increasing the number of units, the area covered can be increased 2 or 3 times. This will reduce the cost of operation considerably.

The field capacities obtained for IRRI's deep plunger USG applicator, IFDC's UB applicator are 0.024 hectare per hour and 0.02 hectare per hour respectively. This is when USG is placed at the rate of one granule for every four hills of seedlings. Then labour requirement is 42 man hours per hectare and 42 to 50 man hours per hectare respectively.

Table 14.

Test : Field capacity and field efficiency
Rate setting - 1 granule/hill

Test No.	Area covered			Total time spent (hours)	Effective field capacity (ha/hr)	Theoritical field capacity	Field efficiency (%)
	Width (m)	Length (m)	Area (m)				
1	0.8	10	8	81.30	0.0123	0.0130	94.6
2	0.8	10	8	81.40	0.0129	0.0137	94.2
3	0.8	10	8	59.77	0.0167	0.0180	93.0
4	0.8	10	8	45.90	0.0218	0.0240	80.7
Average field efficiency (%)							90.63

The main emphasis in this study is to improve the field capacity of the USG applicator. In manual dibbling the labour requirement is 64 women hour per hectare whereas in this case it is only 59 man hour per hectare. Though the saving is marginal, with the incorporation of 8 dibbling units in one applicator and spoked wheels, the field capacity can be increased and the labour requirement reduces considerably.

The performance of the metering mechanism is almost satisfactory. Neverthless, there is a scope for improving it for making it 100 per cent perfect by modifying the fertilizer tube and the spring arrangement. One of the salient features of this implement is its simple metering mechanism.

SUMMARY

A manually operated two-row, two-column USG applicator for wetland paddy field has been developed and tested at the Instructional Farm, Kelappaji College of Agricultural Engineering and Technology, Tavanur. The broad objective of the study is to design, fabricate and evaluate a USG dibbler for placing one USG at a depth of 6 cm in each of the four holes simultaneously. The USG is to be dibbled at the rate of one granule per two hills of paddy.

General lay out and details of the USG applicator

1. There are four spring loaded PVC plungers, which pushes the USG delivered from the fertilizer tube into the holes made in the soil.

2. The four PVC delivery tubes acts as guides for the plungers. Nylon bushes are provided at the bottom of delivery tubes which prevents wearing of delivery tubes.

3. Fertilizer tubes with small hoppers at top end are fixed to the delivery tubes. They guide granules to delivery tube.

4. Main hopper serves as a storage space for fertilizer material.

5. Metering mechanism is a curved spring which is kept in vertical slot just opposite to the delivery hole of the fertilizer tube.

6. A MS flat plate with a curved plate vertically welded to it, jointly act as a stopper to maintain depth of penetration and covering mechanism.

7. A suitable frame is fabricated. Handles are provided to control the applicator by the operator.

8. An operating lever is used for the up and down movement of the plunger.

9. There are two ground wheels of 335 mm diameter on either side of the applicator to transport the implement in the field.

The tests conducted in the laboratory and field have given the following results.

1. The average granule rate observed from the calibration test is 155.8 kg. per hectare, 77.99 kg. per hectare when the application rate is one granule for every two hills and four hills of seedlings respectively.

2. The percentage of the number of granules damaged is 7.8 per cent per unit in laboratory test and is 5.73 per cent in the field.

3. The average number of granules fallen per hole is one during the laboratory test and is 0.95 during field test.

4. The average depth placement is 5.5 cm during sand bed test and 5.98 cm during field test.

5. The field efficiency obtained is 90.63 per cent.

6. The area covered by the applicator is 0.017 hectare per hour.

7. Labour requirement is 59 man hours per hectare.

8. The fabrication cost of the USG including cost of materials is Rs.800/-.

9. The operating cost of the applicator is Rs.16/- per hour and cost of application is Rs.935/- per hectare.

The following defects are noticed during its field operation.

1. Since the operation is intermittent, area

covered per hour is comparatively lower than that of a continuous USG applicator.

2. During the field operation the wheel get stuck in mud.

3. Mechanical damage is caused to some granules because of the compression caused by the plunger.

The following are some of the works suggested for further investigation.

1. Number of units may be increased to 8 or more so that more area is covered per hour.

2. Spoked wheels may be provided to avoid clogging of wheels and for maintaining uniform spacing between adjucent holes in the direction of operation.

3. Mechanical damage can be reduced by use of modified plunger bottom.

4. By the use of adjustable plant to plant and row to row spacing the applicator can be used for different varieties of paddy.

5. The testing of the applicator for different seeds like grams, coupea etc. may be tried with suitable modified metering mechanism.

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APPENDIX-I

Calculation of operating cost of the Urea Supergranule Applicator

Fabrication cost of the USG applicator including cost of material	= Rs 800 /-
Working hours per year(H)	= 200 h
Average life in year(Y)	= 6 years
Average life in working hours	= 1200 h
Salvage value (10 % of the initial cost)	= Rs 80 /-

1. Fixed cost per hour

1. Depreciation $= \frac{C-S}{L \times H} = 0.6$ Rs/hr

2. Interest on average investment (12% per year) $= \frac{C+S}{2\ H} \times \frac{12}{100}$

   = 0.264 Rs/h

   Total fixed cost per hour = 0.6 + 0.264

   = 0.864 Rs/h

11. Variable cost per hour

1. Labour cost = 15 Rs/h

2. Repair and maintenance charge

   (40% of the original price for whole life of the USG applicator) = 0.16 Rs/h

Total variable cost per hour = 15 + 0.16

= 15.16 Rs/h

Total operating cost per hour = 15.16 + 0.864

= 16.024 Rs/h

Area covered per hour = 0.017 ha

Cost of placing the granules = Rs 935 /-

DESIGN, FABRICATION AND TESTING OF A UREA SUPER GRANULE APPLICATOR

By

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ABSTRACT OF THE PROJECT REPORT

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ABSTRACT

A manually operated two-row, two-column USG applicator for wetland paddy field has been designed, developed and evaluated at Kelappaji College of Agricultural Engineering and Technology, Tavanur.

The machine consists of a plunger, delivery tube, main hopper, fertilizer tube, frame, covering mechanism, ground wheel, handle metering mechanism and operating lever. When the operating lever is raised, the plunger takes position just above the delivery hole of fertilizer tube. This permits the entry of granules from the fertilizer tube into the delivery tube. The number of granules is limited to one due to the curved spring provided just opposite the delivery hole. Then the plunger is moved dawnwards by the use of operating lever. The plunger pushes the granule into the hole in the soil made by the plunger. After this operation, the equipment is slightly raised with the handles and the operator moves straight backward so that the delivery tubes are aligned with the next row. The covering of the granule with soil is carried out automatically by the covering mechanism in the above operation. Each unit of the USG applicator is spring loaded so that each one operate individually.

The number of granules dropped is 0.95 per hole in the field trials. The area covered by the USG applicator is 0.017 hectare per hour. The field efficiency is 90.63 per cent. The mechanical damage is 5.73 per cent. The average depth of placement is 5.98 cm.

The cost of the USG applicator is Rs.800/- and operating cost is Rs.16/- per hour. The cost of operation over a hectare is Rs.935/-. The unit is simple in design and can be fabricated locally.