BAUZIA SEED-FERTILIZER DISTRIBUTOR – A NOVEL TECHNOLOGY READY FOR COMMERCIAL USE

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Abstract A manually operated seed-fertilizer distributor was designed and developed in the Department of Farm Power and Machinery of Bangladesh Agricultural University, Mymensingh to broadcast seeds, fertilizers and granular insecticides in the field. Theory of Kinematics of particle and the principle of gravity flow were used in designing the machine. Experiments were conducted for determination of Uniformity Co-efficient of Distribution (UCD), field capacity of the machine and application rate of the seeds (lentil, black gram & wheat) and fertilizers (fine urea & TSP). The UCD of the seeds and the fertilizers were determined by Catching Paper Box method and were compared with that of traditional hand broadcasting method. This simple mechanical device of 6.0 kg weight was designed to carry on the shoulder of an operator during operation. It had a fabrication cost of TK.1000 (US $20) only (in year 2000). Normally, the UCD of traditional hand broadcasting system ranges between 40% to 70%, depending upon the operator's skill. The average UCD of this device at a beater speed of 700 rpm for fine urea, TSP, wheat, lentil and black gram were found to be 97.75%, 93.5%, 88.75%, 97.21% and 96.25%, respectively. The average effective field capacity of the device was calculated as 2.26 ha/hr, whereas it was about 0.32 ha/hr only in case of traditional hand sowing method. The extensive performance tests conducted in the farmers' fields indicated that the seed-fertilizer distributor could be used by farmers with high satisfaction. The technology has already been transferred formally to four machine manufacturers in the country for manufacture and marketing. To day, a good number of machine, known as BAUZIA Seed-Fertilizer Distributor are being used in the field. It is expected that the machine, with its own advantages, will penetrate the farmers world within a very short period of time.

Keywords: Distributor, seed, fertilizer and uniformity

INTRODUCTION

Application of fertilizers and planting of seeds are still performed largely by traditional methods in Bangladesh. Farmers normally use hand-broadcasting method for broadcasting seeds and fertilizers. In this method, seeds and fertilizers cannot be uniformly distributed in the field. As a results, low efficiency and high cost are being incurred. To obtain satisfactory crop yield one should plant particular amount of seed in a given area uniformly. Similarly, fertilizer by hand-broadcasting method cannot be uniformly distributed in the field for which all the plants may not get equal and required nutrients. The principal disadvantage of traditional hand-broadcasting method is the non-uniform distribution of material and thus non-optimal use of resources. Furthermore, it requires experienced manpower to broadcast. It was expected that spreading of seed and fertilizer by mechanical means could be more uniform and achieve high field capacity compared to traditional hand broadcasting.

With a view to minimize the problem, an attempt of designing and manufacturing a seed-fertilizer distributor has been successful. A low cost seed-fertilizer distributor was a necessary for the farmers, that could had solved the sowing problems of both fertilizers and seeds. A seed-fertilizer distributor machine was born in the Department of Farm Power and Machinery of Bangladesh Agricultural University in November 2000. The machine is called as "BAUZIA Seed-Fertilizer Distributor".

Roy and Ziauddin (1992) made an attempt to construct a common device for broadcasting seed and fertilizer. The first version of broadcaster (distributor) machine was not properly designed based on any scientific method. It had no adequate metering unit and slippage occurred due to rope and pulley transmission system.

Ziauddin and Roy (1997) undertook the second attempt to improve the distributor following a design based on kinematics of particle and principles of gravity flow. But the main problem of incorporation of asuitable metering unit remains unsolved. To minimize

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the above problems a third attempt was undertaken with the following objectives;

1) To redesign a seed-fertilizer distributor based on principles of kinematics of particle and gravity flow.
2) To improve the metering and transmission system of the distributor.
3) To test and calibrate the machine for fine urea, TSP, lentil, black gram and wheat.

REVIEW OF LITERATURE

Very limited research works have been conduced so far on a common spreader that can broadcast both seed and/or fertilizer. Most of the works done seemed to be suitable for developed countries. However, no research work has been reported to develop a suitable seed-fertilizer distributor in Bangladesh.
Witek (2000) carried out a study to determine the uniformity co-efficient of fertilizer metering to the working assembly of a disc spreader as affected by fertilizer dose, level of container filling and lay out of fertilizer bedding in the container. Low values of uniformity co-efficient ranging from 1.42 to 3.26% were stated.

Kaminski (1999) investigated the effect and relationship of design and operation parameters and their influence on application efficiency and developed an optimization technique for disc spreader operation and verified it in practice. Investigations and estimation showed that the key factor influencing fertilizer application rate per hectare had only a slight influence on the spreaders working width. Further application efficiency proved to be greatly dependent on the spreading disc diameter, number of blades, disc rotational speed and the height of discs above the ground. The method presented was tested in practice and was used to optimize settings for spreading discs under different operating conditions.

Ziauddin and Roy (1997) developed and tested a low cost seed-cum-fertilizer distributor for broadcasting seeds and fertilizer in the field. The materials to be distributed fell down by the gravity from a tank on a fixed metallic platform. A hand-operated rotor distributed the materials uniformly. This simple mechanical device was designed to carry on the shoulder of an operator during operation. The Uniformity Coefficient of Distribution (UCD) of traditional broadcasting system was about 30% to 43% depending up on the labour skills. But the average UCD of this device was about 82.32%, 80.43% and 85.66% for the fine urea, granular urea and wheat, respectively.
Tajuddin (1989) designed, developed and tested a hand rotary-broadcasting device for broadcasting seeds, fertilizers and granular insecticides in laboratory and field. The uniformity co-efficient of distribution was determined for spreading urea using the broadcasting device and compared with that of the hand broadcasting process. The device could coverage of 1.26 ha/hr in paddy. The unit had a weight of 3.6 kg and cost of US$ 55 and average Uniformity Coefficient of Distribution (UCD) was 50% only.

"CECOCO", a Japanese company worked on granular spreader (broadcaster) and reported that this particular spreader become popular because chemicals for weed out grass and broadcasts the fertilizer in a granule form. It was so easy to handle and required no water and even a small quantity was adequate and economical when compared with other forms. It broadcasted all kinds of small seeds. Both manually operated and battery operated version of the facility were available. The field capacity ranged from 20 to 40 acres/hr and had a spreading radius of 4 to 7 meters.

Galili *et al.* (1988) designed a prototype vertical fertilizer spreader and tested under laboratory and field conditions. The experimental results were used to calculate the effective swath width and uniformity of distribution of the new spreader. Optimum swath widths of 54m and 27m were calculated for granular superphosphate and urea, respectively, with a coefficient of variation better than 15%. A moderate side wind did not affect the swath width but reduce the uniformity of distribution.

Sato (1988) investigated spreading performance of a wide swath fertilizer spreader with modified distribution blades. Blade design and number were evaluated with the objective of reducing vibration and improving uniformity of spread. The influence of wind direction and speed on distribution was also studied.

MATERIALS AND METHODS

Five different types of techniques are available today to spread small particles in the field. These are;

1) Spinning disc type distributor
2) Distributor type rotor
3) Pneumatic distributor
4) Oscillating spout machines
5) Plate and flicker machines

The rotor type mechanism was selected because of simplicity of fabrication and operation. The material to be distributed, could be kept in a tank from where it may fall through an opening by gravity flow on a platform. During gravity flow of material on the platform, a rotating beater may broadcast the material at a desired rate. The beater could be powered by an arm of an operator.

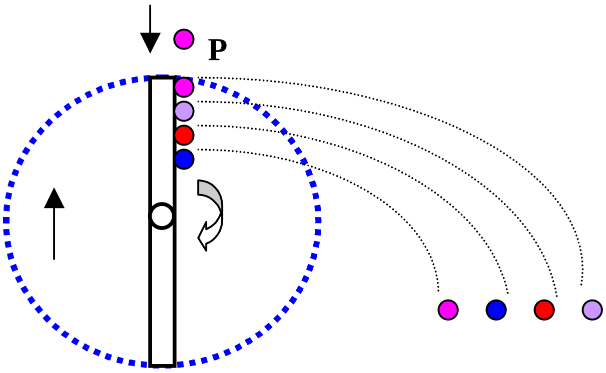

Fig1. Circular motion of a beater arm and curvilinear motion of a particle

Design of Beater

The length of the beater arm was designed using the principle of circular motion and plane curvilinear motion of particle. Circular motion of a beater arm and curvilinear motion of a particle are represented by the Fig. 1. The vertical and horizontal distance traveled by a particle, P due to beating action of a beater is shown in Fig. 2. The velocity of a point on the beater is

$$V = \omega r = 2\pi N r \quad \text{........................} \ (1)$$

Where, V = velocity in m/s
ω = angular velocity in rad/min
N = rotor rpm, and
r = length of beater arm in m.

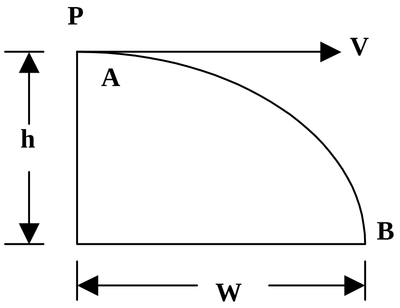

Fig2. Plane curvilinear motion of a particle

The fertilizer or seed as hit by the rotor arm at the point P travels through the path AB (Fig. 2) and obtains final velocity, *V*, before it drops on the ground. The horizontal distance (*W*) travelled by the material could be found from the equations of plane curvilinear motion of particle, which is

$$W = V\sqrt{\frac{2h}{g}} \quad \text{..} \ (2)$$

Where, h = height of beater arm from the ground during operation in m

g = acceleration due to gravity in m/s^2 and
W = horizontal distance (swath width of the distributed material) in m.

Equation (1) and equation (2) give

$$W = \frac{2\pi N r}{60}\sqrt{\frac{2h}{g}} \quad \text{or}$$

$$r = \frac{60W}{2\pi N}\sqrt{\frac{g}{2h}} \quad \text{..} \ (3)$$

For reasonable values of h =1m, N = 700 rpm and W = 5.0 m, the value of r becomes 0.151 m. Thus two beater arms each 0.151 m length at an angle of 180^0 was considered in designing the beater.

Test Procedure

The performance of a broadcaster is usually indicated by UCD, field capacity and application rate. The following test procedure was adopted to determine UCD, field capacity and application rate for selected seeds (wheat, lentil and black gram) and fertilizers (fine urea and TSP).

Test for UCD

The Uniformity Co-efficient of Distribution (UCD) is the key parameter of the distributor and it was determined using the following formula and Catching Paper Box method.

$$UCD = 1 - \frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n\bar{x}} \quad \text{...................................} \ (4)$$

Where, $\bar{x}$ = average weight of materials of all boxes.

x_i = weight of materials in each box; and

n = number of boxes kept for the test.

Test for Effective Field Capacity

The effective field capacity is calculated using,

$$F = \frac{SxWxe}{10}, \text{ ha/hr} \ \ldots (5)$$

Where, S = Actual average walking speed , kph
W = Actual width of material spreaded, meter.
e = Field efficiency

Test for Application Rate

Application rate of the materials depends on the discharge rate of material and the actual field coverage by the distributor. The application rate of the material (kg/ha) for different hopper opening was calculated using the following relationships.

Application rate of materials, $A = \frac{D}{F}$, kg/ha …..... (6)

Where, D = Actual discharge rate of materials, kg/hr
F = Effective field capacity of the machine, ha/hr.

RESULTS AND DISCUSSION

Brief Description of the Machine

The BAUZIA Seed-Fertilizer Distributor consists of a hopper, agitator, beater, crank, freewheel, gear, pinion, receiving platform, a metering unit and a frame. The total weight of the machine is 6.0 kg when empty and has an overall dimension of 310mm x 380mm x 700mm.The materials to be distributed are contained in a hopper and allows to fall by gravity on a receiving platform through a metering unit, from where the materials are distributed by a rotating beater as shown in the Fig. 3. The platform is fixed horizontally with the frame just below the hopper. A sliding-door type of metering unit is placed at the bottom of the hopper that maintains the required opening at the bottom of the hopper thereby controlling the amount of seed or fertilizer to be distributed. The beater has two wings that offered beating action to the materials to be distributed uniformly. The beater is powered through a chain sprocket, freewheel, and gear-pinion system. A wooden handle is attached to the sprocket through which the sprocket is powered by operator's hand. The distributor could be carried on the shoulder of an operator with the help of two adjustable cotton belts and could be operated by the right hand of the operator. There is an agitator at the bottom of the hopper, which contains four spikes. The agitator helps prevent clogging of materials and maintains uniform and continuous feeding on the receiving platform. The distributor unit was fabricated in the workshop of the Dept. of Farm power and Machinery, Bangladesh Agricultural University, Mymensingh. The complete pictorial view of the BAUZIA Seed-Fertilizer Distributor in operation is shown in Fig. 4.

Performance of the machine

The performance tests of the machine were performed mainly for Uniformity Co-efficient of Distribution (UCD), application rate and field capacity. Walking speed, operator's skill, beater's rpm, discharge rate and wind velocity etc. are the factors that influence the performance of the device. Sensitivity tests were also conducted with variable beater rpm and hopper opening. Three types of seeds (lentil, black gram and wheat) and two types of fertilizer (fine urea and TSP) were taken to conduct the experiment. Tests were conducted for distribution of seeds and fertilizers both for traditional hand sowing and machine sowing. Experiments were carried out on a plot of 5m x 20m. It was divided into 80 small blocks of 1 meter square. Forty catching paper boxes of size 220mm x 220mm x 90mm were placed at the centre of each block. Materials (seed or fertilizer) were allowed to distribute using the machine at a constant walking speed (4 kph) for different predetermined hopper openings and beater rpm over the boxes. The weight of material discharged over each box, the corresponding time and the beater speed and wind velocity were determined. The UCD, effective field capacity and application rate of the machine were calculated using equation (4), equation (5) and equation (6), respectively. Also, similar procedures were followed to determine these parameters for hand-broadcasting method. During experiments no adverse effect of wind was observed as the velocity of wind remained between 43.41 m/min to 54.55 m/min.

The average UCD of the device (at the beater speed of 700 rpm.) for fine urea, TSP, wheat, lentil and black gram were found to be 97.75%, 93.50%, 88.75%, 97.21% and 96.25%, respectively (Table 1). It was observed that the UCD for all seeds and fertilizers increased with the increase of beater speed. However, UCD for fine urea gradually decreased with the increase of beater speed beyond 700 rpm. (Fig. 5). The Fig. 6 shows that the UCD decreased with the increase of hopper opening. Because of increased hopper opening it delivered larger quantity of materials at a time. As a result all the particles could not receive uniform beating action. Thus slightly low UCDs have been observed, especially for wheat
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The application rate of fine urea, TSP, lentil, black gram and wheat were found to be 17.587 to 106.32 kg/ha, 13.72 to 108.53 kg/ha, 21.00 to 40.88 kg/ha, 30.88 to 46.66 kg/ha and 106.83 to 152.09 kg/ha, respectively (Table 2). Figure 7 indicates the application rate of materials increases very insignificantly with the increase of beater speed. But it increases significantly with the increase of hopper opening (Fig. 8).

The average effective field capacities of the distributor were calculated to be 1.903, 2.115, 2.565, 2.529 and 2.196 for fine urea, TSP, lentil, black gram and wheat, respectively (Table 1). It was observed that the average effective field capacity of the machine was over 2.26 ha/hr where as it was only 0.32 ha/hr for traditional hand sowing.

Table. 1 shows the comparison between hand broadcasting and machine broadcasting. The average effective field capacity of the machine was 7 times higher than that of traditional hand broadcasting method. The overall cost for machine-sown materials has also been reduced by 7 times. The average UCD of the machine-sown of the materials was found over 95% having a standard deviation of 3.70. However it was found 73.94 % in case of hand broadcasting with a standard deviation of 10.86 . The results of the performance tests of the machine indicate that the machine broadcasting system was found significantly better than the traditional hand sowing system.

Table - 1: Comparison between hand-sown and machine-sown system

Item	Material	Machine sowing	Hand sowing
E.F.C (ha/hr.)	Fine Urea	1.903	0.32
	TSP	2.115	
	Lentil	2.565	0.32
	Black gram	2.529	
	Wheat	2.196	
UCD (%)	Fine Urea	97.75	83.18
	TSP	93.50	55.93
	Lentil	97.21	81.81
	Black gram	96.25	74.71
	Wheat	88.75	74.07
Over all cost (Tk/ha.)	Fertilizer	4.35	27.34

Table –2: Results of calibration of the distributor at a beater speed of 700 rpm.

Knob position	Opening %	Materials	Application rate (kg/ha)	Width of coverage (m)
0.75	9.37	Fine Urea	17.587	5.4
		TSP	13.720	6.6
1.0	12.5	Fine Urea	37.373	5.5
		TSP	29.290	6.6
		Lentil	21.00	6.1
1.5	18.75	Fine Urea	71.820	5.6
		TSP	39.030	6.6
		Lentil	40.880	6.1
		Black gram	30.880	6.0
2.0	25	Fine Urea	106.32	6.0
		TSP	72.990	6.6
		Black gram	46.660	6.1
2.5	31.25	TSP	108.53	6.6
		Wheat	106.83	5.3
3.0	37.5	Wheat	132.64	5.4
3.25	40.62	Wheat	152.09	6.1

Calibration of the machine

Calibration of a machine is nothing but identification of different points on the dial gauge for various application rates of the materials. Knob positions for each crop at various application rates were identified and marked on the dial gauge. It would help farmers to select the correct knob position for desired rate of application. The results of calibration are shown in Table 2.

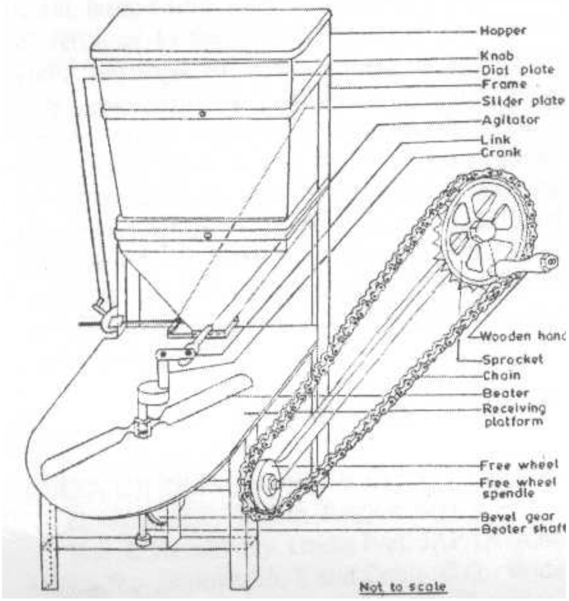


Fig3. Components of BAUZIA seed-fertilizer distributor

Fig4. BAUZIA seed-fertilizer distributor in operation

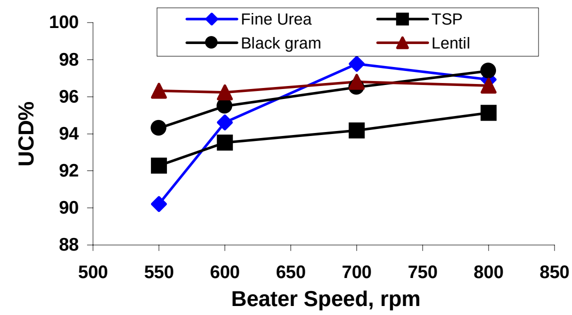
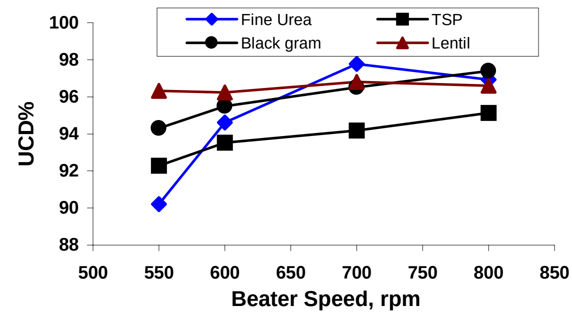


Fig.5 Uniformity Coefficient of Distribution at various beater speed with knob position at point 1.5 (18.75% opening).



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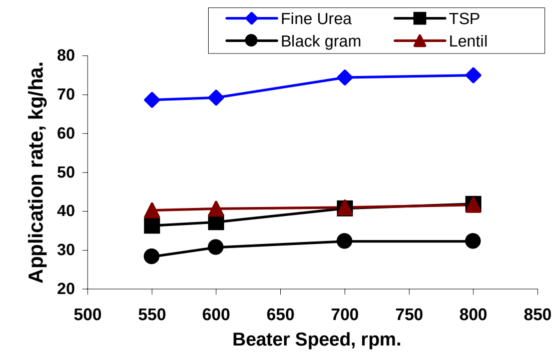

Fig. 7 Application rate of input at different beater speed with knob position at point 1.5 (18.75% opening).

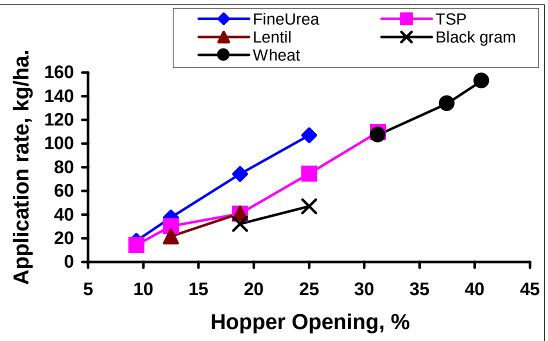

Fig. 8 Application rate of inputs at different hopper opening for beater speed of 700 rpm.

CONCLUSIONS

The BAUZIA Seed-Fertilizer Distributor is a manually operated simple device, having a fabrication cost of TK. 1000 (US$20) only (in the year 2000), can distribute many types of agricultural seeds (such as wheat, lentil, black gram etc.) and fertilizers (such as urea, TSP, MP). The distributor is capable of spreading seeds or fertilizers at a uniformity index of over 95%. The maximum effective field capacity of the device was found to be 2.56 ha/hr. This simple mechanical device of 6 kg in weight was designed to carry on the shoulder of an operator during operation. It was recommended that the machine should be operated at a normal walking speed of 4 kph and a comfortable hand rotation for the chain-sprocket system. The BAUZIA Seed-Fertilizer Distributor could offer an excellent uniformity of distribution and could save significant amount of time and money and reduce drudgery. The machine is considered environment friendly and free of health hazard since there is no scope of physical contact of fertilizer to the farmer. It may also increase crop yield. Investigation of the impact of the machine on crop productivity is in progress. The technology has already been transferred formally by Bangladesh Agricultural University to four machine manufacturers in the country for manufacture and marketing. The patent registration is in progress. A good number of machine is being used by the farmers in the field. It is expected that the machine, with its own advantages, will penetrate the farmers' world within a very short period of time.

REFERENCES

CECOCO "Providing the world with more Food & Employment". Eighth Edition Series No. 1, P.O. Box 8, Ibaraki city, Osaka Pref. JAPAN. (undated).

Galili, N.; Shmulevich, I. and Coble, C.G. Wide swath vertical type centrifugal spreader. Transactions of the ASAE, American Society of Agricultural Engineers. 31(1) p. 58-62. (1988).

Kaminski, J.R. "Application efficiency of solid mineral fertilizers". Warsaw, Poland; Institytut Budownictwa, Mechanizacjii Elektrifykacji Rolnictwa p. 41-46. Rolnictwa Oddzial W Kludzienkii, Poland. (1999).

Roy, P and Ziauddin, A.T.M. "Development of Seed-Cum-Fertilizer Distributor", Unpublished report, Department of Farm Power and Machinery, BAU, Mymensingh. (1992).

Sato, J. "Studies on Development of wide swath fertilizer spreader (Part III). Improvement of the wide swath fertilizer spreader and the particle motion analysis in the wind". Journal of the Japanese Society of Agriculture Machinery 50(5) p. 49-56. National Agric. Res. Cent. Kannondai 3-3-1, Tsukuba. Ibaraki, Japan. (1988).

Tajuddin, A. "Design development and testing of hand rotary broadcasting device for seeds, fertilizers and granular insecticides". Agricultural Mechanization in Asia, Africa and Latin-America (AMA) 20(1) p. 41-44. (1989).

Witek, A. "Uniformity of fertilizer metering to the working assembly of a disk spreader". Problemy Inzynieri; Roniczej 8(1) p. 11-17. Katedra Maszynoz nawstwa Rolniczcjo, Akadamia Rolnicza, Lublin, Poland. (2000).

Ziauddin, A.T.M. and Roy, P. "Design and Development of a seed-cum-fertilizer distributor for small farm holders". Journal of the Institution of Engineers, Bangladesh (Agril. Engg.Division), Vol. 25/AE No.1. (1997).