OPERATION MANUAL

POWER TILLER

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Overseas Technical Cooperation Agency

P R E F A C E

This hand book, one of the OTCA Technical Hand Book Series was prepared by the staff-members of Pak-Japan Agricultural Extension Training Institute in East Pakistan as a guide book for the operation and maintenance of Japanese Power Tillers in East Pakistan.

It is hoped that this hand book will serve useful purpose for the application of power tillers in South and South East Asia and contribute to the agricultural development of the countries in the Region.

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66. Operation Manual for the Power Tiller

Introduction.

Power tiller is a Japan made agricultural implement, which was remodelled to adapt itself to the rice cultivation.

Power tiller, which had been first used only for the ploughing, has recently been utilized for all the cultural practices. The East Pakistan Government, which was reatly interested in the performence of this power tiller, is said to have the intention of importing 420 units of this tiller in 1965.

In this manual, we have chiefly described practical requirements for the maintenance and operation of Japanese power tiller to be newly introduced. In order to master the maintenance and operation technique, the understandings through the practice is the best way. In this connection, this manual should be then put to practical use for information.

Contents

I. Features of the Power Tiller

Power tiller is a machine, which conducts a ploughing operation, by driving ahead the ploughing unit fitted on the rear of the machine. It is very high in efficiency, as the ploughing and soil crushing are given at the same time, by the rotation of the ploughing claws. (Fig. 1). It is, therefore, especially suitable for farmers of rather big holding, or the areas where the winter crop of short plough period is given. As the power tiller ploughs the soil finely from the first, it is good for such an area of heavy clay as East Pakistan, where it is difficult to crush the soil over again, once the filled soil is dried.

Such a situation as mentioned above is also conceivable from the process of development of power tiller in Japan. When the crushing of heavy clay soil in the reclaimed land in the southern part of Okayama prefecture was found very difficult, the power tiller of Shiema type was first imported from Switzerland in 1920 on trial to settle the problem. Getting hint therefrom, the present power tiller has been devised.

Though the fine soil crushing is required for making preparation for the sowing of broadcast AMAN and AUS rice plants, the tiller, especially of rotary type is most suitable. If the iron wheel is fitted, meanwhile, the tiller can be utilized for the ploughing and puddling of the transplanted AMAN, AUS and BORO rice plants in a submerged status. It has also displayed a good performance in the ploughing, harrowing and hilling of regetable farms. In the meantime, it can be used for the cultivation and weeding works of banana and papaya orchard. If the tiller is equipped with fertilizing and sowing units, it can be utilized for the fertilization and sowing works of the broadcast AMAN and AUS rice plants, wheat and barley, pulse, rape, etc. If further researches are made, it could be also used for the planting of jute. The use of fertilizing and sowing machine not only increases the efficiency of planting work and subsequently the yield through the enhancement of working accuracy, but also improves the efficiency of weeding and harvesting works.

When a pump is fitted on the front of power tiller, various crops can be watered. When the ploughing unit is removed, and a trailer is fitted, meanwhile, the power tiller can be used for the transportation.

As for the number of power tillers used in Japan, it was only 13,000 units in 1951, and then increased to 1,700,000 units in 1964. Thus the power tiller has become a nucleus of the agricultural mechanization. Such a rapid diffusion of power tillers indicates their fitness for the agriculture in Japan. Though East Pakistan is different from Japan in ground condition, etc., they are similar to each other in the small-scale farms chiefly based upon the rice crop at least. In this connection, we are very sure that the power tiller would be very useful for the agricultural mechanization in East Pakistan

Fig. 1 Soil crushing work by means of power tiller.

II. Sorts of the Power Tiller

Though there are many kinds of power tillers, they can be classified into the followings: traction-type, driving-type, traction and driving type. The traction type pulls such a tractive working machine as the plow-harrow cultivator, when it is used (Fig. 2). The driving type conducts the ploughing and stamping at the same time, when a driven ploughing unit is fitted on the rear of power tiller. It is exclusively used for the ploughing and soil crushing. (This type has recently been also remodelled so that it can be equipped with manuring and seeding units). The ploughing unit is divided into three types: rotary, crank and screw types. At present -- Fig. 2 Traction-type power tiller, model 31 --, however, the rotary type is mostly used. In Japan, the traction and driving type has been most widely used, because it is equipped with both merits of the traction and driving types. In East Pakistan, too, this traction and driving type would be suitable. We shall, therefore, describe chiefly the power tiller of this type in the followings.

III. Construction of the Power Tiller

Driving type, and the tractive driving type function, when the power is transmitted not only to the wheels but also to the working unit. This type is shown in the Fig. 3 and 4. Though many power tillers of different types are made, they are almost the same in major parts. In general, the power tiller is made of the following parts:

1. Engine

This is a device converting the thermal energy into mechanical energy, which is generated, when the gasoline, kerosene, light oil, etc. are burnt. This power runs the power tiller, or -- Fig. 3 - 4 Construction of the power tiller -- drives the working unit.

2. Transmission gear

It is a transmission gear, which transmit to the running and working units the power generated by the engine. This gearing is made of clutch, speed change gear, final drive unit, etc.

3. Running unit

It consists of wheels and other units for the run of power tiller. Tiller is generally equipped with rubber wheels. Iron wheels are used for the puddling and ploughing works of submerged fields (Fig. 5). There are many kinds of iron wheels. Especially when the ground is soft, iron wheels of large lugs and diameter are generally used to prevent the sinking of power tiller, and obtain the propulsion force required.
-- Fig. 5 Iron wheels --

4. Controlling unit

Handle is equipped with various control levers to start and stop the power tiller, and change its speed.

5. Brake unit

Tiller is equipped with a brake unit for the safe run.

6. Working unit

Working unit is made of 2 ploughing unit of rotary or screw type, traction unit for hauling the working unit, and a device extracting the power required when other working machine is driven by the power of power tiller.

IV. Equipments for the Operation

1. Main clutch handle and main clutch

When the main clutch handle is put forward to the position "In", power is transmitted by gears to start the power tiller. When the clutch handle is restored to the position "Off", power is cut to stop the power tiller. Clutch is a very important part, which is operative not only for the start and stop of tiller, but also for the disconnection between the engine and the change gear at the change of speed. As for the clutch, there are many systems. In general, however, disc clutch and V-belt clutch are used. Disc clutch can transmit and interupt the power exactly and very smoothly. In principle, the receiving disc is pressed against the turning disc to receive the turning effort required. In order to cut the power, discs should be kept off each other. These operations are controlled by the clutch handle. In case of the V-belt clutch, clutch handle is controlled to operate the tension pulley so that the tense belt may transmit the power. When the clutch handle is placed on the position "Off", the belt becomes lax not to transmit any power. Because of its simple mechanism, it cannot display a performance of clutch, unless it is fully adjusted.

2. Main speed change lever and the transmission gear

There is a speed appropriate to the quality of each work, in accordance with the working condition, meanwhile, it is necessary to reduce the speed properly so that the turning effort large enough to overcome the load may be given to the wheels. When the power tiller is backed, furthermore, the revolution reverse to the turning direction at the forward motion must be given to the wheels. It is a transmission gear, which is used for such a purpose as mentioned above. Transmission gear is a combination of several sets of gears, through which running speeds of several stages can be obtained. The number of stages, and the running speed are shown in the instruction manual. There are generally 3 - 6 stages for the forward motion, and 1 - 2 stages for the backward. This change of speed is controlled by means of speed change lever. In changing the speed, clutch must be switched off.

3. Direction clutch lever and the steering gear

When the power tiller changes its running direction, the wheel of the curving side must turn at a speed lower than that of the other. The steering gear of power tiller is a gearing of clutch system, in which a pair of clutches are engaged with each other by virtue of spring before the final reduction gear. When the direction clutch lever of the right side is grasped, the right-side clutch is disengaged, the left-side wheel runs faster than the right-side, and the tiller turns to the right side.

4. Brake unit

Brake unit of the power tiller is generally used only for stopping and parking the tiller. In most power tillers, brake unit of outer contraction system, or inner expansion system is fitted on the intermediate shaft from the change gear to the wheel shaft. Many brake levers are also used as the clutch handle, when the clutch handle is further pulled from the "Off" position, the brake becomes operative.

5. Speed control lever

Speed control lever, which is fitted or the handle, controls the revolution of engine. It is used for giving a revolution suitable for each operation, and controlling the speed at the revolution of power tiller. Its control is possible at the root of handle.

6. Handle

Power tiller handle holds the tiller body. During the work, meanwhile, a small curve could be corrected, by shaking the handle, not using the clutch.

V. Maintenance before working

Maintenance work before the starting and after the end of the operation of power tiller is very important to use the power tiller safely, smoothly and economically. However carefull the operation of power tiller during the work may be, it cannot display its perfect performance so fully as not to achieve a good work record, and would be out of order midway

to frustrate the schedule of work, if it is not in a good state of repair. In some case, the damaged parts would inflict a serious injury on the operator.

In connection with the above, the proper operation refers not only to that during the run of power tiller, but also the repair before its run, and the custody after the work. Operator, who cannot handle the power tiller properly before and after its run, could not be called the "decent operator". Prior to the operation, operator should observe the followings:

1. Operator's dressing

Though it does not directly relate to the maintenance before the operation, untidy dress of operator would be partly rolled into the revolving parts of power tiller. As it is very dangerous, operator should be dressed tidily.

2. Checking, and the supply of oil and fuel

i) Whether any part is broken, or out of order

Damage and trouble should be found as early as possible. They should be treated until they become serious. Parts shall be checked to find whether bolts and nuts are loosened, or not. Lax points should be more rightened. Above all, set bolts and nuts of the engine, wheels, ploughing claws, etc. shall be exactly checked, because they would be easily relaxed.

ii) Whether the belt is tensed properly

When the belt is loose, it slips not to transmit the power satisfactorily. When it is too tense, however, it would be seriously abraded. When the belt waves, or makes a great noise during the run, it comes from its looseness. When the belt is beated, or seriously worn, it comes from its too much tension. In tensing the belt properly, it should be first fixed so that the center line of the engine and the power tiller pulley may be straight. Its proper tension should be so much that the middle of belt would drop by 0.5 - 1 inch, when it is pushed by the tip of finger.

iii) Whether the main clutch functions properly

If the clutch is not fully disengaged, even when the main clutch handle is placed on the "Off" position, it is very dangerous, because the power tiller is not yet stopped. At the gear change, meanwhile, improper operation of the clutch would damage the gears, and subsequently affect other portions greatly. In order to check whether the clutch works properly, or not, speed change lever shall be first placed on any optional position to turn the engine manually on trial. If nothing is wrong, power tiller ought to be inoperative, when the clutch bandle is on the "Off" position. When it is on the "In" position, the power tiller would start its run.

In case of the V-belt clutch, the length of main clutch wire, and the setting of tension pulley shall be so adjusted that the tension pulley may rise much enough to tense the V-belt, when the clutch is switched "In", and that the V-belt may loose perfectly, when the clutch is switched "Off". If it does not go well, even when the above adjustment is given, the setting position of engine shall be adjusted.

In case of the disc clutch, the length of clutch wire shall be adjusted. When the clutch is not well operated, it shall be reduced. When the clutch slides, it shall be increased. In case this adjustment cannot put the clutch into order, adjustment shall be given by means of spring adjusting screw. If the screw is screwed in, the spring powerfully acts upon the disc. If the screw is loosened, the spring action is reduced. When the clutch is found slipping, therefore, the screw should be tightend.

iv) Whether the tiller is smoothly steered

The point of checking is to try to push the power tiller, by gripping the direction clutch levers, left and right. In this case, the tiller shall move slightly. When the hands are taken off the levers, the tiller shall not move easily. When the direction clutch is not well operative, the clutch wire shall be adjusted, by reducing its length.

v) Checking of the air pressure of tires

When the air pressure is different between the tires, left and right, the power tiller does not go straight ahead. It cannot be operated, because the handle is taken to the tire side of less air. In this connection, the specified air pressure (16.5 lbs per 1 inch^2) should be given equally to the left and right tires each.

vi) Checking and the supply of engine oil

Under any circumstances, checking and supply of engine must not be neglected. When the oil is found running short at the checking by oil level gauge, it shall be additionally supplied. If the oil runs short, the engine is seriously stained, or the improper oil is used, piston, piston rings, bearings would be burnt or worn out.

1) Function of the engine oil

When the metals of the machinery comes into direct contact with each other to make a friction, the resistance becomes large, and subsequently their friction surface is seriously abraded. There is also a danger of the metal surface being melted and burnt by heat. Oil makes a film on the friction surface, which prevents the metals from coming direct contact with each other. When this film is formed, the friction is reduced, the machine is slightly run, and the abrasion of friction surface is curtailed. Therefore, oil is used for every friction part of the machinery. Especially in case of engine, which turns at high speed, temperature and pressure, the function of lubricating oil is very important. The effects of engine lubricating oil shall be enumerated hereunder:

(1) Friction and abrasion can be reduced

(2) Film between the piston and the cylinder prevents the gas from venting to give the gas tightness.

(3) Carbon soot formed in the cylinder head, metalic dust in friction parts and other foreign matter are dissolved and taken away in the oil. Thus the oil has a purging effect upon all the parts of the machine.

(4) Oil has the function of cooling the highly heated inside of engine.

(5) Oil prevents the metals from rusting.

As mentioned above, oil has many important functions. If the lubrication is worsened, therefore, the running condition is immediately affected to cause a fatal fault in the engine. In this connection, the engine oil shall be checked and supplied before the use of tiller so that the oil may not run short during the run. All the stained engine oil shall be discharged and changed with the new every 40 - 50 working hours, by taking off the oil drain plug.

2) Choice of the engine oil

Selection of the lubricating oil would greatly affect the durability and maintenance of engine. Oil to be used shall be chosen on the basis of viscosity and quality. As the maker specifies in the instruction manual the oil in accordance with the expected temperature, operator shall observe this specification. In relation to the oil classification based upon the viscosity, the S.A.E. number prescribed by the U.S.A. Society of Automative Engineering is internationally used. As for the viscosity index of the S.A.E., oil is classified in terms of viscosity alone. It does not indicate the quality and performance of oil. In the instruction manual, the maker specifies the S.A.E. number of the oil to be used in accordance with the temperature. Typical S.A.E. number shall be shown hereunder.

90°F and over	32° - 90°F	Below 32°F
SAE - 40	SAE - 30	SAE - 20

(2) In respect to the oil classification based upon the quality, the A.P.I. standard made by the American Petroleum Institute has been most widely used (Table 1). Service classification mark, M in the Table 1 refers to the oil for the gasoline or kerosene engine, while the D to the oil for the Diesel engine.

Table 1: Classification of the engine oil according to the API Prescription

Service Classification	Definition	Additive %
ML	Jump-spark ignition engine of small size, which is fueled with gasoline or petroleum, and engaged in a very slight work	0
MM	Jump-spark ignition engine, which is engaged in a medium-grade work	0.5 - 0.2
MS	Jump-spark ignition engine, which is often stopped, moved or engaged in a heavy work	2.0 - 4.0
DG	Compressive ignition engine such as the Diesel, which is engaged in a general work	2.0 - 4.0
DM	Compressive ignition engine, which is engaged in a medium-grade work	
DS	Compressive ignition engine, for which the fuel of poor quality is used, or the engine equipped with supercharger, which is engaged in a heavy work	

We should like to recommend the MS-grade oil for the gasoline or kerosene engine fitted in the power tiller. It is, meanwhile, desirable to use the DM or DS-grade oil for the Diesel engine fitted in the power tiller. In making choice of the engine lubricating oil, proper oil shall be carefully selected according to the above S.A.E. number indicating the viscosity, and the A.P.I. standard showing the quality and performance of oil.

vii) In checking and supplying the lubricating oil

For the main body of power tiller, too, the oiling points, sort of oil and the oil quantity specified in the instruction manual shall be strictly observed. As the specially important points are equipped with oil level gauges for checking, they shall be checked. If the oil is found short, it shall be additionally supplied. Though the points to be oiled and checked vary with the sort of tillers, the main gear box and the ploughing chain case shall be charged with gear oil.

When the new power tiller is used for 30 hr. for the first time, all the oil shall be renewed. After that, the oil shall be exchanged periodically once a year. Metal of the ploughing shaft shall be greased.

viii) Checking and supply of the fuel

Fuel shall be checked, as the engine would not run without fuel. Quality and purity of the fuel to be used would greatly affect the duration and efficiency of engine. The storage of fuel is a major item relating to the maintenance of engine. Especially in the Diesel engine, the mixing of water and small dust into the fuel would often put the fuel pump and nozzle out of order.

-- Fig. 6 Example of the fuel tank

The Fig. 6 shows an instance of the fuel tank, which could be simply made of a drum. Fuel discharging cock shall be laid on a position, approx. 6 inches above the bottom. If so, fresh fuel can be extracted, because the dust and water mixed into the fuel deposit on the bottom. Drain cock shall be opened once a year to discharge the deposits and the water-mixed fuel to clean the inside. Discharged fuel can be used as the washing oil at the repair of engine and power tiller. Container of oil and the hopper shall be kept in the locker, or covered to retain its cleanness.

ix) Checking and the supply of cooling water

If the tiller is driven, the cooling water being left short, the engine temperature would become approx. 1200^{o} - 1600^{o} each explosion. Subsequently the lubricating oil would not function, and the piston and cylinder would be burnt for a small time. Cooling water shall be as fresh as possible, and be all discharged from the drain cock once three days, and exchanged for the new. Prior to the use of power tiller, it shall be constantly checked whether the cooling water runs short during the use, or not.

x) Preparation of tools

A minimum number of tools required on the farms shall be prepared without fail.

VI. Operation of the Engine

1. Jump-spark ignition engine

Jump-spark ignition engine has the following two types: gasoline engine, for which the gasoline is chiefly used, and the kerosene engine for which the kerosene is chiefly used.

i) Gasoline engine

1) Main clutch of the power tiller shall be disengaged. It shall be then confirmed that the speed change lever is positioned neutral. When the clutch is left engaged, the engine cannot be started easily.

2) Cock of the fuel filter shall be opened. There is a fuel filter midway, when the fuel is sent from the fuel tank to the carburetor. Filter cock shall be opened to send the fuel to the carburetor. Fuel filter is a device, which filters the dust is fuel, and feeds the fresh fuel to the carburetor. If any sediment is found in the filter, it shall be taken off, flushed with fuel neatly and set in.

3) Choke lever of the carburetor shall be pulled.

Choke lever is operated at the starting to limit the air flowing into the carburetor, increase the concentration of mixed gas and make easy the starting. When the engine is warm, the choke lever operation is not needed. If the engine is started and a little warmed, choke lever shall be returned as early as possible.

4) Throttle lever shall be placed on a position, approx. 1/3 - 1/2.

Throttle valve is a valve, which adjusts the quantity of mixed gas flowing into the combustion chamber. When the throttle valve is opened to increase the suction quantity of mixed gas, the revolution of engine is raised.

5) Starting rope shall be wound on the starting pulley and drawn vigorously

Starting rope shall be tightly wound, and drawn first from the compression position. If the rope is not drawn from the compression position, the strength would not be sufficient to obtain a high revolution, and consequently the engine could not easily be started. If this operation is repeated 3 - 4 times, engine would generally be started. If it is not started, something is wrong with the engine. Operation shall be stopped to find the fault as early as possible. If the operation is continued, the engine would suck too much gasoline to start easily. In case it sucks too much gasoline, choke valve shall be fully opened.

6) Warming the engine

If the engine is started, as mentioned above, choke lever shall be returned, throttle valve be closed a little, and the engine shall be run at low speed for 3 - 4 min. Revolution shall not be increased, and the power tiller shall not be moved until the engine is warmed up enough. When the engine is cool, oil is so high in viscosity

as not to flow easily and distribute fully to the parts to be lubricated. If the engine is then run at high speed, or loaded, it would be seriously worn out to reduce its life remarkably. Engine shall be, therefore, driven at low speed to be warmed until it reaches the running temperature. The performance of engine during its warming run shall be then checked. If nothing is found wrong, the following operation shall be started.

7) Cooling the engine

When the engine is stopped, too, like in case of the starting, it shall be stopped after its low-speed run for 2 - 3 min. If the engine is stopped at high temperature, the oil would be dried by heat, and the engine would run for a while in a status of no oil at the next starting. In this connection, the engine shall be run at low speed for 2 - 3 min. to decrease the temperature slowly so that the oil may go round fully. Such a run is called the cooling run, and very important to maintain the life of engine for a long time. When the cooling run is finished, the stop button shall be pushed to stop the revolution.

ii) Kerosene engine

Gasoline is generally used to start the kerosene engine. If the engine is started, the gasoline is replaced by the main fuel, kerosene. Fundamental operation for the starting and stopping is the same as that in case of the gasoline engine.

2. Diesel engine

Diesel engine is an engine, in which the air in the cylinder is compressed powerfully, the fuel is jetted therein, and exploded by spontaneous ignition.

i) Preheating run

Fuel lever shall be placed on the "non-injection" position, the compression be released by the reducing lever, and the non-loaded run be given 10 - 20 times by means of starting handle. When this operation is

given, oil goes round to each part, and the perfect lubrication is possible at the starting. As the Diesel engine is especially in need of high compressive force, it cannot be easily started due to the gas leakage, unless the lubricating oil fully permeates between the pistonrings and the cylinder. Therefore, this preheating run is a very important operation.

ii) Starting

When the preheating run is finished, the cock of fuel tank shall be opened, throttle lever be placed on the 1/3 - 1/2 position, and the starting handle be turned to check the injection of fuel. If the fuel is injected, when the starting handle is turned, injection noise can be heard. When any abnormal noise is then heard, air shall be vented, because there is air in the fuel system. When the engine is in need of gasoline for its starting, small quantity of gasoline shall be injected into the inlet hole of air cleaner. When the ignition paper is used, it shall be tightly inserted into the ignition paper holder. When the engine is started again immediately after its stopping, neither gasoline nor ignition paper is required. Starting handle shall be turned as quickly as possible, being gripped by hand. When the engine is equipped with a decompression lever, compression shall be released by this lever, and then the handle shall be turned. When the engine is run by inertia, decompression lever shall be taken off the hand. When the handle is further turned rapidly, overcoming the compressive force, the engine is started. If nothing is wrong with the run, power tiller shall be moved to start the work after the warming run for 2 - 3 min.

iii) Stopping method

Stopping method is the same as that in case of gasoline engine. When the throttle lever is placed on the "stop" position after the warming run for 3 - 4 min. fuel would not be injected to stop the engine.

VII. Fundamental Operation for the Run of Power Tiller

Though the operation for running the power tiller is somewhat different among the sorts of works, fundamental operation shall be first mastered.

1. Start

It shall be confirmed that the clutch is disengaged. If the speed change lever is positioned neutral, even when the clutch is engaged, power tiller is at a standstill. If the speed change lever is operated, even though the clutch is engaged, the gears would come into collision with each other, and make noise the moment they are engaged. If such an error is made in operation, the gears would be worn out early. At the worst, the gears would be broken. Clutch shall be exactly disengaged, and the speed change lever shall be placed on the required position. In case of the motorcar, etc., the speed is accelerated from the first, second and third gears to the high. When the power tiller is to be run at high speed, the lever should be first placed on the required position. Thus the tiller can start its run at the high-speed gear position. If the clutch is then suddenly engaged, however, the engine would stop, or the power tiller would dash. Clutch shall be, therefore, gradually engaged very carefully. At higher running speed, engine would be loaded more greatly. If the tiller is run at high speed for such a heavy work as the ploughing, accordingly, it would stop, emitting black smoke. Checking the condition of engine, operator should use the power tiller at a proper gear position. If the tiller is run too fast in the sowing, etc., meanwhile, no good result cannot be obtained. If the speed change lever is placed on a proper position, throttle lever shall be drawn to increase the engine speed, and then the clutch shall be quietly engaged. After such an operation, the power tiller shall start its run.

2. Stopping

Clutch shall be disengaged. In case the tiller does not stop by virture of inertia, even if the clutch is disengaged, brake shall be further applied. At the same time when the clutch is disengaged, throttle lever shall be restored to decrease the revolution of engine. Speed change lever shall be positioned neutral. When the

operator goes off the power tiller, he must always brake it.

3. Turning

As it is dangerous to turn at high speed, throttle valve shall be returned to decrease the revolution of engine, and then the turning action shall be conducted at safe speed. If the working unit is lifted, and the clutch of the turning side is disengaged at the same time when the throttle lever is returned, the power tiller would turn.

Operator shall be well trained in three actions of switching off the throttle lever, lifting the working unit and disengaging the steering clutch. If the turning comes to an end, steering clutch shall be returned, and the throttle lever shall be drawn to increase the revolution of engine.

4. Backing

After confirming that the clutch is disengaged, speed change lever shall be switched into the back gear position. Unless special care is taken, the handle would rise by reaction force in case of backing. Handle shall be tightly held so that the clutch may be disengaged at any time.

5. Straight run

Straight run without curving is a fundamental of the driving operation. When the power tiller does not run straight on the farms, good result cannot be expected therefrom. In order to move the power tiller straight forwards, care shall be taken about the following points:

i) Regardless of the motion of power tiller, operator shall drive it with his face turned upwards to the target carefully.

ii) Strength of the shoulder shall be weakened, and handle shall be held lightly. In an easy posture, operator shall drive the tiller. If the operator presses the handle too strong, the tiller would wind.

iii) If the power tiller begins to turn aside, it shall be corrected by handle so much as it turns. If operator trys to correct the tiller by switching off the steering clutch, it would often make the tiller wind.

iv) If the air pressure is unequal between the power tiller wheels, left and right, or the tail wheel does not turn smoothly, the tiller would not go straight. Prior to the run, therefore, perfect maintenance shall be given.

6. Crossing over the hills and obstacles

Unless the tiller is carefully driven in passing over the hills of paddy fields, and the obstacles, it would be not only damaged by impact, but also the operator would be swung around. This is very dangerous. In passing over these obstacles, the speed change lever shall be first put on the "first gear" position to run the tiller on to the hill of paddy field quietly. In this case, tiller shall be braked, stopped once, and then descend quietly after the clutch is engaged. If the crossing is felt dangerous, plank shall be laid over so that the tiller may cross over safely.

7. Run on the ascent

When the power tiller ascends the slope, the speed change lever shall be switched into the low before the ascent. Lest the speed should be changed midway on the upward slope, because the large force is required for the ascent. If the clutch is disengaged confusedly to operate the speed change gear, as the engine is likely to stop midway on the ascent, the power tiller would change its run by the self-weight, and be suddenly drawn back, as the power of engine is cut off. When the speed is to be changed inevitably midway on the upward slope, clutch shall be disengaged, brake be fully applied at the same time, and the speed change lever be quickly switched over. If the steering clutch is disengaged on the ascent, the power tiller would turn aside suddenly to cause a great danger. On the ascent, therefore, care shall be taken about the steering operation.

8. Run on the descent

Run on the descent is more dangerous than that on the ascent. Therefore, special attention should be paid to the drive. According to the grade, speed change lever shall be first placed a proper position so that the tiller may descend at as safe a speed as possible. As for the engine revolution, the engine shall be run at low speed by operating the throttle lever. Engine brake shall be then applied so that the tiller may descend at moderate speed.

Engine brakage is a sort of braking effect made by the engine: When the power tiller runs down a steep slope, its motion is curbed by the compression of the low-speed running engine, and the friction resistance of parts. As the engine brake is more effective at lower speed, gears shall be changed into the low speed on a steep descent. Tiller shall then descend quietly, clutch being engaged. In case the slope is very steep, the slope is rugged even though it is gentle, or the road ground is soft, it would be safe, if the tiller runs down, the backgear and the engine brake being applied.

9. Run in the muddy water

In East Pakistan, the power tiller must be used in the muddy water to make the grounds for the transplanted AMAN and AUS, and BORO rice plants. If the steering clutch is gripped for a long time for the sideway turning, when the tiller is driven in the muddy water, only the wheel of one side would be loaded, it causes the wheel submerged into the paddy field. In this connection, steering clutch shall be operated intermittently.

When the power tiller is driven in the muddy water, part of the tiller would be submerged in the muddy water, and further often splash mud. When the power tiller is not well repaired, muddy water would infiltrate into the inside of machine to cause the trouble. Prior to the drive, loosened bolts and nuts shall be fully tightened. Above all, it shall be checked whether the oil leaks into the chain case, or not. If any oil leakage is found, there is a danger of the muddy water infiltrating therefrom.

After the work, tiller shall be well washed, and the drain plugs of chain and transmission cases shall be

taken off to drain a little oil. It shall be then checked whether the muddy water is mixed into this oil, or not. If the muddy water is mixed, the oil is stained whitish. In this case, treatment is required after checking from where the muddy water comes in. Oil shall be, needless to say, renewed.

As the run in the muddy water imposes a severe load upon the machine, operator shall repair it carefully before and after the run.

10. When the power tiller is used in a very dusty place.

When dust rises very much in the ploughing operation, etc., or the tiller is used as a motor for the threshing operation, all coupling sections from the air cleaner to the air inlet pipe shall be checked, and locked so tightly as not to be loosened. When the work comes to an end, air cleaner shall be checked without fail, its inside be washed, and the soiled oil shall be renewed.

VIII. Handling after the Run, and the Cares about the Keeping in the Shed.

During the time from the end of daily work to the keeping of power tiller in the shed, the followings shall be strictly observed:

i) Engine shall not be stopped immediately.

Engine shall not immediately be stopped, but after the non-load run at low speed for 3 - 4 min. When the engine is stopped at high temperature, oil sticking to the piston, cylinder, piston pin, crankshaft, etc. would be dried to make difficult the starting on the following day. Therefore, the engine shall be turned quietly before the stop. It shall be stopped after the temperature decreases gradually.

ii) Washing and checking of the power tiller

If the run is finished, the power tiller shall be washed and cleaned without fail. This operation does not only cleans the machine, but also is useful for finding the looseness of bolts and nuts, breakage of parts, oil leak and other faults at early stages. It is, therefore,

important for the operator to make a habit of cleaning the machine, however busy he may be.

iii) Indoor keeping of the machine

As the power tiller is a costly machine, and has many exposed parts, it would gather rust easily, when it is exposed to the wind and rain. At any cost, therefore, it shall be kept indoors.

iv) Treatment of the clutch

If the discclutch is left disengaged, clutch spring would remain contracted for a long time to hasten the fatigue of spring. If the driving plate is kept off the pressure plate, meanwhile, dust would come into the clearance to cause the slipping.

v) Confirmation of oil supply and tools

All oiling points shall be lubricated. It shall be confirmed whether all the tools, which had been carried to the farms, are complete, or not.

IX. Sorts and Characteristics of Various Operation Units Attached to the Power Tiller

1. Tiller

There are three types of tillers: rotary, crank and screw types. It is the rotary type, which is used most at present. The tiller of rotary type conducts the ploughing and soil crushing operations at the same time, when its ploughing shaft equipped with the claws turns at the revolution of 150 - 200 per sec. The magnitude of soil stamping can be controlled over a considerably wide range, when the revolution of ploughing claws, advancing speed, sort and the number of claws, etc. are changed. The rotary type is simple in construction, and inexpensive, as it can be made easily. It can be used for the puddling and intertillage. Its application is very wide.

2. Hilling unit

In case the farms are ill-drained, and the crops are

subject to the damp like the vegetable crops in rainy season in East Pakistan, it is necessary to raise the seeding bed. If the crops are sown on the flat ground, meanwhile, this unit can be used as the furrowing unit. When the hilling unit is fitted on the rear of the rotary unit, ploughing and hilling operations are given at the same time. Hilling unit is so devised that the height of hill may be changed to some extent.

3. Puddling unit, paddy field wheel and the plank harrow

When the puddling is given by the rotary unit, auxiliary rotaries are fitted on both sides of the rotary to enlarge the corking width in some case wheels are replaced by paddy field wheels, and the puddling is conducted, by turning the rotary. Simple plank hallow is trailed to roll the ground evenly. Plank harrow is also used for the ground making for the dried fields. Plank harrow has the some function as that of the "ladder" used by farmers in East Pakistan.

4. Fertilizing and sowing unit

Most of the power tillers can be equipped with fertilizing and sowing units. In this unit, the feeder and the hopper for the fertilizer and seed are fitted on the front of handle, the furrowing unit on the rear of the rotary, and both units are coupled through the pipe. When the seed delivery roll is replaced, the unit can be used for sowing rice, wheat, barley, pulse and regetables, etc. As for the sowing system, broadcast and drill sowings, either of them, are possible. Fertilizing and sowing quantity, and the sowing depth can be adjusted over a wide range. As for the covering soil, soil, which is finely crushed by the rotary, is used. As the ground is then stamped by the roller, the germination is excellent.

5. Water pump

In East Pakistan, irrigation is required for the crops on the farms and the BORO rice in dry season. Thus the function of water pump is very important. In the Pakistan-Japan Agricultural Extension Training Institute, a water pump is fitted on the front of power tiller so that the pump may be driven by the engine of power tiller (Fig. 3). Such a system is very economical, because no time is required for setting the pump, and the power

tiller engine can be utilized.

6. Trailer

When the ploughing unit on the rear of power tiller is removed, and the working unit setting device is equipped with a trailer, the tiller can be used for the conveyance (Fig. 8)

-- Fig. 7 Water pump directly coupled with the power tiller

-- Fig. 8 Trailor fitted in the power tiller

X. Ploughing and Harrowing by Means of Power Tiller, and its Working Capacity

1. Characteristics of the ploughing by means of power tiller

Objective of the ploughing lies in tilling the soil to the proper depth, stirring, crushing, expanding and softening the soil.

a) to extend the growing range of roots.

b) to make an air and moisture condition favorable for the germination of seeds.

c) to promote the decomposition of nutrients in the soil and make even their distribution.

d) to remove the weeds and harmful matters in the soil, etc.

In order to achieve the above objectives, it is necessary to crush a certain depth of soil into a definite size, and further roll the soil surface evenly.

Soil in East Pakistan is generally clayish. If it is dried, it is so much solidified that the ploughing work becomes very difficult. In Feb. 1964 a ploughing test in the Institute on a very much dried paddy field, where the AMAN rice had been harrested in the previous year yielded the following record (Table)

Table 1:	per acre	
	Required time (%)	Fuel consumption (%)
Dry field	160	130
Properly wet field	100	100

Operation was very difficult, on the dried field as the body of power tiller oscillated much. As the ploughing work thus becomes very difficult, when the soil is dried, the soil must be ploughed while the water remains properly in the soil after the harvest of the previous crop.

Soil crushing operation shall be given in rainy season in Mar. - Apr. Even if the soil is stamped while it is dried, it would cost much labor and have little effect. In dry season when the moisture evaporates rapidly, a ploughing device, which would make the soil retain the moisture for as long a time as possible, is required. If the surface soil is finely crushed, the surface is rapidly dried, but the soil 10 inch deeper than the surface is not so much dried. In obtaining such a sowing bed, power tiller is an ideal ploughing and harrowing machine.

2. Ploughing operation of the power tiller

When the power tiller reaches a farm.

a) fixed pipe tightening handle shall be first loosened,

b) depth adjusting screw guide shall be greatly lifted,

c) guide shall be adjusted to the approximate depth,

d) speed change lever shall be switched into the first or second gear according to the ground condition,

e) ploughing speed gear shall be switched into the high or low, (Relation between the combination of the running speed change with the ploughing

speed change, required horsepower and the soil crushing is shown in the Table 2).

-- Table 2: Effect of the combination of the running speed change with the ploughing speed change upon the required horsepower and the soil crushing

Running speed change	Plowing speed change	Required horse-power	Soil crushing extent
First gear	Low	least	secondly fine
	High	secondly much	finest
Second gear	Low	thirdly much	finest
	High	most	thirdly fine

f) clutch shall be engaged to start the ploughing work after switching in the speed change lever and the ploughing speed gear,

g) and the control shall be given by the depth adjusting handle in any case the ploughing depth is smaller or higher than the required depth.

3. Ploughing method and the working capacity

i) Level ploughing

Ploughing method must be devised to meet the ground condition. General method shall be described hereunder.

In case of level ploughing, as shown in the Fig. 10, farm should be ploughed, some width remaining unploughed, and then the remaining portion should be later ploughed. In this case, the remaining

-- Fig. 9, Fig. 10 Ploughing method --

width shall be smaller than the ploughing width so as

not to leave any non-ploughed portion. If the ploughing in a longitudinal direction is finished, both ends shall be ploughed at the end of the work. Such an adjacent reciprocal ploughing method as shown in the Fig. 9 is not favorable because the power tiller is tilted, and the ploughing ground is inconstant. When the "hatchet-shaped claws" are used, the setting direction of claws shall be as shown in the Fig. 11.

— Fig. 11 Setting direction of the "hatchet-shaped claws" at the ploughing

As a large horsepower is required for the first ploughing, both running and ploughing shaft speed change gears shall be switched into the low position. Working capacity of the power tiller is as shown in the Table 3.

Table 3 Ploughing capacity of the power tiller (at the first plowing)

Engine H.P.	Sort of the ploughing unit	Ploughing depth, inch	Poughing speed Ft/Sec	Required time, min/acre	Fuel consumption gallon/acre
3.5	Rotary	5.3	1.2	524	2.2
4.5	"	5.5	1.5	400	2.5
6.0	"	4.9	1.3	344	2.4
8.0	"	5.6	1.5	264	2.4
5.0	Plow	5.6	3.0	320	2.6

ii) Soil crushing operation

In relation to the braodcast AMAN and AUS rice plants, well crushed soil would make the soil stick closely to the seeds, and promote the germination. It is, therefore, desirable to crush the surface soil into lumps of less than 1 inch diameter each. After the harvest of the previous crops, first ploughing shall be given, and then soil shall be crushed 1 - 2 times after the rainfall. In the soil crushing, the speed change gear of the ploughing shaft shall be switched into the high, while the speed change gear for the ploughing shall be placed into the second speed. In setting the ploughing claws, they shall be put in-and outward in combination as shown in the Fig. 12. Working method is the same as that

-- Fig. 12 Setting of the "hatchet-shaped claws" at the soil crushing --

of the level ploughing previously mentioned. Working efficiency of the soil crushing is almost twice as high as that at the first ploughing. Fuel consumption per acre is $\frac{1}{2}$ of the first ploughing. In other words, when the power tiller of 8 HP. capacity is used, 2 hr. and 15 min. are required per acre, and the fuel consumption is 1.8 gallon.

Crushing of the soil lumps at the crushing work varies with the moisture of soil. In any case when the soil is too wet, or too dry, it would be unfavorable for the crushing. As it is the optimum moisture condition when the soil is easily crushed by hand, crushing work shall be done during the proper period after the rainfall without fail.

iii) Hilling ploughing

-- Fig. 13 Setting of the claws, and ploughing in case of hilling ploughing --

In case of the hilling ploughing, claws shall be first put inward as shown in the Fig. 13, No. 1. Alike the level ploughing shown in the Fig. 10, ploughing shall be given every other travel. For the second place, as shown in the Fig. 13, No. 2, all the claws but one claw of both ends each shall be put inward. When the harrowing unit is then fitted as shown in the Fig. 14 to plough the remaing portion, hills can be neatly made. Working efficiency is almost the same as that in case of the first ploughing at the level ploughing (refer to the Table 3)

-- Fig. 14 Harrowing unit fitted in the power tiller--

iv) Hill breaking ploughing

In case of the hill breaking, as shown in the Fig. 15, furrows shall be first ploughed, and then the hills shall be ploughed as, if they are broken down to both sides. Except two claws of both sides, ploughing claws shall be put outward. Working efficiency is almost the same as that in case of the level ploughing.

v) Puddling for the paddy fields, and the harrowing for the upland fields.

In the puddling work, the tiller shall be equipped with paddy field wheels, as it is put into the submerged fields. Especially in paddy fields, where the soil is soft, a power tiller of so small a capacity as approx. 4.5 HP is desirable. Meanwhile, wheels for the wet fields must be used in reference to the claw setting at the puddling, claws shall be put in-and outward as shown in the Fig. 16. In order to make even the field surface, such a simple harrow plate as shown in the Fig. 17 shall be tied to the depth adjusting screw guide, and the operator shall ride on the plate in driving the tiller. In such an order as shown in the Fig. 16, puddling work shall be given length-and crosswise. When the puddling work is given twice, approx. 120 min. are required per acre. As the puddling work aims to make the field surface evenly flat, various methods must be devised in accordance with the height of field surface regardless of the above-mentioned way. In preparing the soil of upland fields, harrow plate, which had been used for the puddling, shall be utilized. Function of this plate is almost the same as that of the MAI, which is generally used by farmers in East Pakistan. When the harrowing is given twice, approx. 100 min. are required per acre. Working method is the same as that in the pudding.

— Fig. 16 Claw setting and working method in the pudding and ground making operations —

— Fig. 17 Rolling work by means of harrow plank —

XI. Utilization of Fertilizing and Sowing Machines, and Their Working Efficiency

In East Pakistan, the Broadcast AMAN and AUS rice seeds are broadcast. Their area under cultivation is not small. When the fertilizing and sowing units are used for these rice plants, the efficiency of sowing operation can be not only improved, but also the weeding and harvesting labor can be saved by means of drill planting system.

In 1965 when the power tiller with fertilizing and sowing unit was tested for the broadcast AUS rice plants, good results were obtained, and the sowing operation was possible as expected. Fertilizing and sowing unit can be used not only for the rice but also for the wheat, barley, pulse, vegetable, etc. In East Pakistan, it is a working machine which shall be widely useful. In this connection, its details shall be described in this paragraph.

1. Kind of the direct sowing machine

Fertilizing and sowing machine is divided into the following types: drive sowing and traction sowing types. As shown in the Fig. 18, the drive sowing type unit can conduct ploughing, stamping, manuring, sowing, covering and tamping works in a process. It is very efficient. In case of the broadcast AMAN and AUS rice plants, ploughing and stamping operation must be almost twice given, because the weed grows, unless the ploughing work is given by the sowing period. This type can be fitted in the power tiller, which can conduct a drive ploughing operation. In the meantime, the traction type is an unit, in which the fertilizing and sowing unit is hauled by the power tiller as shown in the Fig. 19. Before the sowing, therefore, ploughing, soil stamping and preparation must be given.

-- Fig. 19 Traction-type sowing machine --

-- Fig. 20 Drive-type manuring and sowing machine --

As the type of fertilizing and sowing unit to be fitted is dependent upon the sort of power tiller, special care shall be taken, when it is purchased.

2. Construction and action of the fertilizing and sowing machine

Fertilizing and sowing machine consists of power transmission gear, fertilizer and seed delivery unit, grounding unit, etc.

i) Power transmission gear

Unit, which transmits the power from its source to the fertilizer and seed delivery unit, is called the "power

transmission gear". In many types, seed and fertilizer are generally delivered, when the delivery roll is turned. This revolution is usually approx. 30 - 100 r.p.m. because it is limited by the property of seeds and fertilizer. As the revolution of delivery shaft is thus low, tilling shaft or power tiller shaft is used as a power extracting shaft. As for the order of power transmission, almost as shown in the Fig. 20, sprocket is fixed to the power extraction shaft, and chained, and the power is transmitted in order of intermediate shaft, fertilizing unit shaft and sowing unit shaft.

-- Fig. 20 Power transmission mechanism of the fertilizing and sowing machine

In the fertilizing and sowing machine of traction type, grounding wheel makes a power source of the delivery unit.

ii) Delivery unit

Delivery unit is the major section of fertilizing and sowing machine, which delivers evenly a definite amount of seed or fertilizer to each drill without damaging it. Though there are various types of seed delivery units, such a horizontal roll type as shown in the Fig. 21 is most in number.

-- Fig. 21 Seed delivery unit

Delivery unit of this type consists of hopper containing the seed, delivery roller giving a revolution, brush cutting the seed, receiver getting the delivered seed, and the control mechanism adjusting the delivery. Delivery quantity is controlled, when the roll is shifted to the left or right to adjust the working width of delivery slit. As for the

fertilizer delivery, there are various systems. Roll type or turning bottom system is generally used.

iii) Grounding unit

Grounding unit is an unit coming into contact with the ground. Its function has the largest effect upon the germination and growth of seed. As shown in the Fig. 22, prounding unit of the drive sowing type machine consists of ploughing unit, fertilizing and sowing pipes, and tamping roller. In case of drill planting, it shall be set as shown in the Fig. 22. In case of direct sowing, however, fertilizing and sowing pipes shall be set in front of the ploughing claws, fertilizer and seed be dropped, and mixed with the soil by claws, and the soil be tamped by roller. In case of drill planting, sowing depth shall be controlled by virture of plough depth based upon the lifting of roller. Row spacing shall be controlled, when the setting position of fertilizing and sowing pipes is adjusted.

3. Preparation for the sowing

Fertilizing and sowing unit shall be so completely set as not to be loosened on dislocated during the work. Set fertilizing and sowing unit shall be well checked, fertilizer and seed delivery unit be taken off and its turning portions be lubricated. Seed to be used shall be perfectly freed from dust, straw, stone, etc. Above all, fertilizer shall be well crushed and sieved.

4. Adjustment before the sowing

When the adjustment opening for the delivery of fertilizer and seed is gradually enlarged, the delivery is gradually increased. For instance, test records of the KUBOTA-made KMB-200 model power tiller equipped with the fertilizing and sowing unit, model FR-3 (experiment place: Agricultural Extension Training Institute, Tejgan) are shown in the Figs. 23 and 24.

— Fig. 23 Characteristics curve for the seed delivery AUS rice plant: Variety, Kataktara (22 g. per 1,000 grains)

Number of the dropping seed grains per foot (per pipe)
Adjustment scale
Running gear, Ploughing gear
Sample machine.
Power tiller, KUBOTA KMB-200

-- Fig. 24 Characteristics curve for the fertilizer delivery (Ammonia chloride)

The above curves are called the "Characteristics curves for the fertilizer and seed delivery. As the power for driving the delivery unit was extracted from the tilling shaft in the above sample machines, the characteristics curves for the delivery varied with the position (High or low speed) of the running speed change gear as well as the ploughing speed change gear.

Quantity of speed delivered is greatly dependent upon the size and shape of grains. Before the work, therefore, adjustment shall be given. Adjustment shall be then given again after checking whether the required number of seed grains (approx. 20 grains for the AUS rice plant) are dropped per foot, or not, when the tiller is run, the seed being not covered with soil. This is also the same with the fertilizer. The soil depth shall be a little small, when the soil is wet. When the soil is dry, meanwhile, the depth shall be large. In general, the proper soil depth is 0.5 inch. The covering soil depth shall be controlled by the ploughing, when the roller is lifted or dropped by the depth adjusting handle as mentioned above.

Sowing operation shall be given in such a way as the close ploughing method shown in the Fig. 25. When the wheel track of power tiller is 26 inches. The hill with shall be 13 inches, and the tiller shall run along the previous wheel tracks. If so, the wheel tracks would function as the markers to make the work more easier.

-- Fig. 25 Method of the sowing work --

The time required per acre is 4 hr. when the hill width is 13 inches, and the speed gear is positioned first.

It is 2 hr. and 30 min., when the speed gear is positioned second.

— Fig. 26 Sowing work for the AUS rice plants by means of drive-type fertilizing and sowing machine.

Fig. 1 Soil crushing work by power tiller

Fig. 2 Driving type

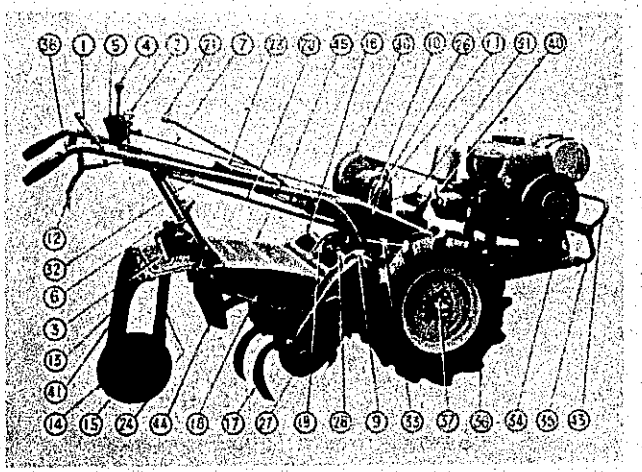


Fig. 3 Structure of power tiller

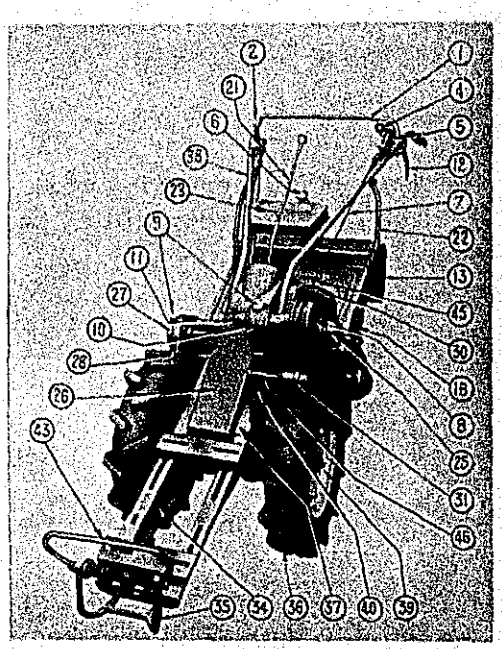


Fig. 4 Structure of Power tiller

Fig. 5 Iron wheels

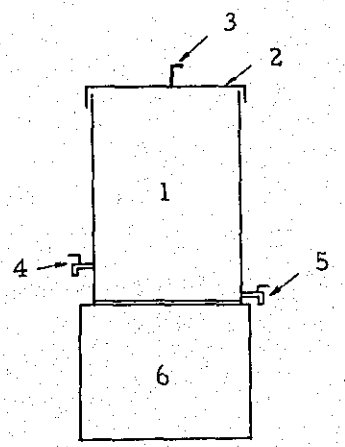


Fig. 6 Example of Fuel Tank

1 Tank
2 Tank cover
3 Air vent
4 Fuel discharging cock
5 Drain cock
6 Base

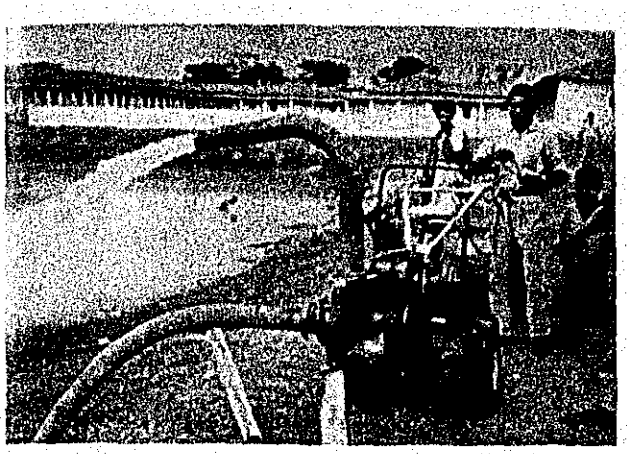


Fig. 7

Water pump directly coupled with the power tiller

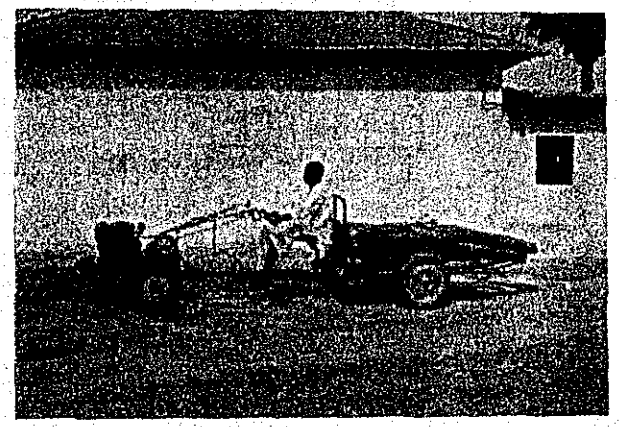


Fig. 8

Trailor fitted in the power tiller

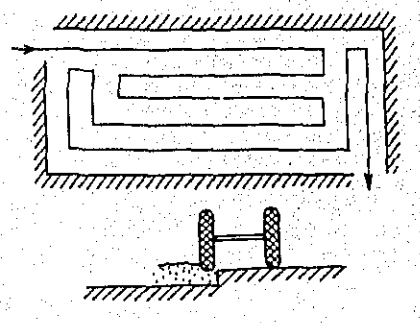


Fig. 9

Ploughing method I

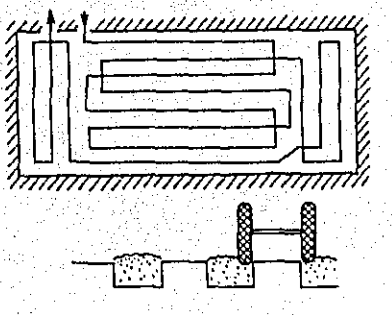


Fig. 10

Ploughing method II

Fig. 11

Setting direction of the "hatchet-shaped claws" at the ploughing

Fig. 12

Setting of the "hatchet-shaped claws" at the soil crushing

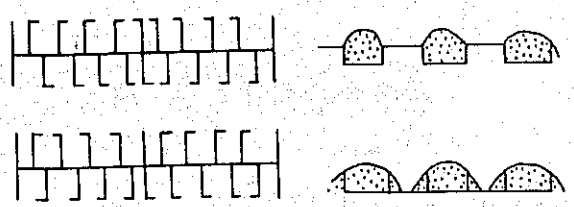


Fig. 13

Setting of the claws, and ploughing in case of hilling ploughing

Fig. 14

Harrowing unit fitted in the power tiller

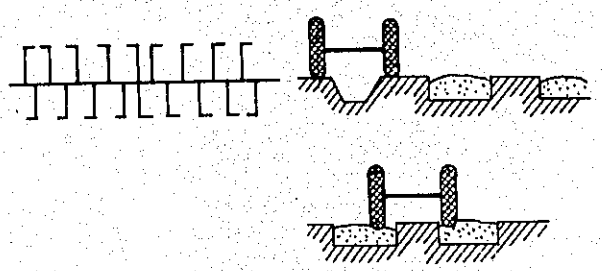


Fig. 15

Claw setting and working method
in case of hill breaking ploughing

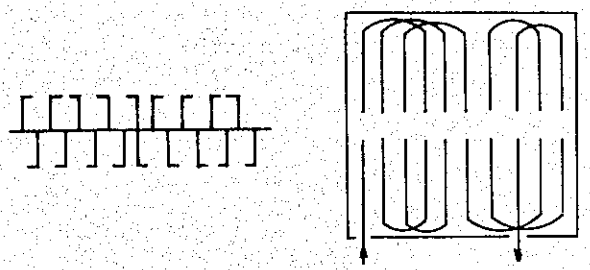


Fig. 16

Claw setting and working method
in the puddling and ground making
operations

Fig. 17

Rolling work by harrow plate

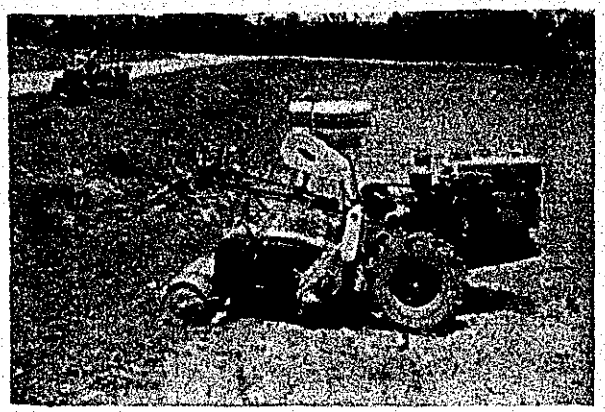


Fig. 18 Drive-type sowing machine

Fig. 19 Traction-type sowing machine

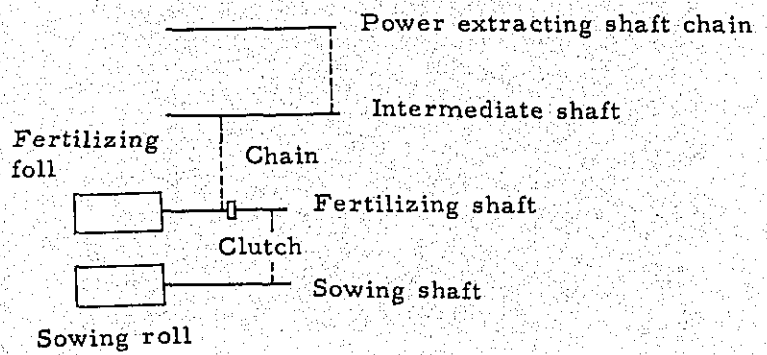
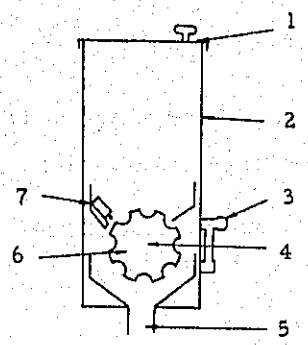


Fig. 20

Drive-type fertilizing and sowing machine



1. Hopper cover
2. Hopper
3. Adjusting lever
4. Sowing shaft
5. Receiver
6. Roller
7. Brush

Fig. 21 Seed delivery unit

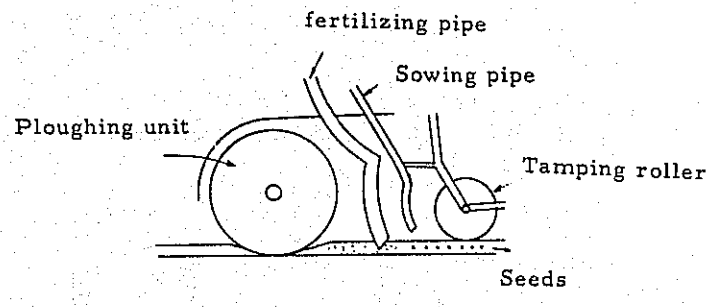


Fig. 22

Grounding unit of driving-type fertilizing and sowing machine

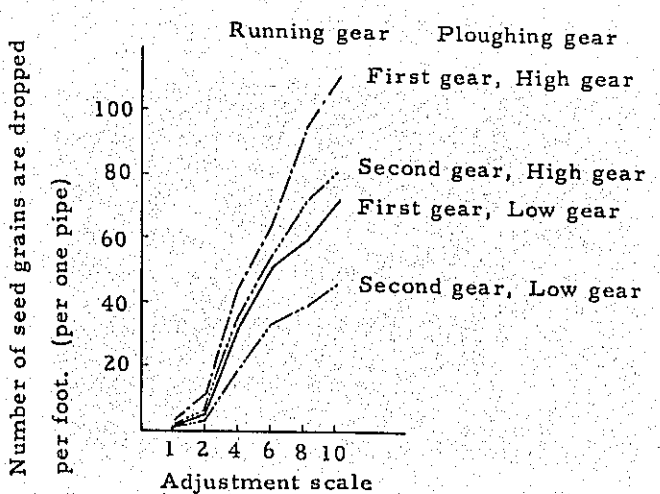


Fig. 23 Characteristics curve for

Characteristics curve for the seed delivery

Variety: Aus, Kataktara (22 per 1000 grains)

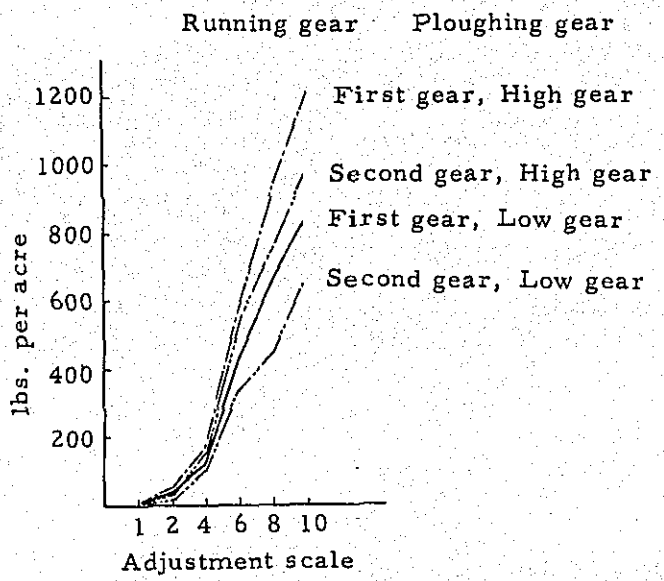


Fig. 24

Characteristics curves for the fertilizer delivery (Ammonia chloride)

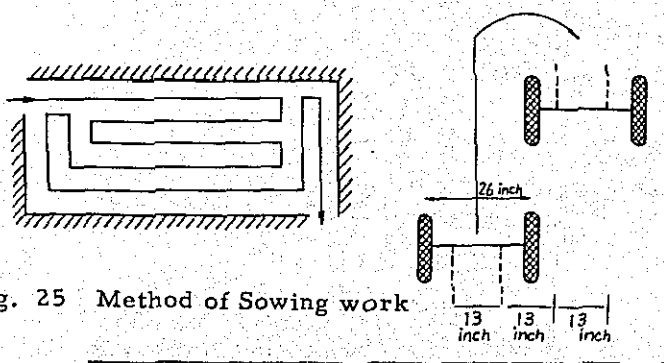


Fig. 25 Method of Sowing work

Fig. 26

Sowing work for the Aus rice plants by drive-type fertilizing and sowing machine