Pak. J. Agri. Sci., Vol. 21 (3-4), 1984

AGRICULTURAL MECHANIZATION – RESEARCH, DEVELOPMENT AND PLANNING

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ABSTRACT

Planning related to agricultural machinery must not be carried out on the basis of speculations and interviews. Information regarding the performance of equipment alongwith its economic feasibility is usually needed for developing an appropriate mechanization strategy. Further, the mechanization basis used by developing countries may be misleading for Pakistan. For example, it was recommended by a worker from a friendly country that Pakistan must plan to achieve the level of power equal to about 0.6 H.P. per hectare. Such a basis has not been found reliable in view of our agricultural conditions. This paper suggests a plan for increasing tractor population and discusses the suitability of different tractors, tillage implements, grain drills, transplantors, threshers and harvesting equipment, from the standpoint of their technical performance and economic feasibility.

INTRODUCTION

As each age progresses, it brings with it the momentum of knowledge gained from the adventuring of the mind and body. New ideas face bitter opposition in the beginning, since human beings are basically conformist in their attitudes and thinking. When steam locomotive was invented, people avoided to travel by it with many fears in their minds. The use of fertilizer in our agriculture has been another example. Similar is the case with agricultural mechanization in Pakistan. The introduction of tractors brought the fear of displacement of labour amongst our minds. Consequently, the mechanization process received a considerable set back in the beginning. Tractors were imported in limited numbers and their assembly and production in Pakistan

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remained a debatable issue for many years till the beginning of 1970. Nevertheless, it is heartening to realize that the number of tractors in Pakistan has been increasing with gradual receptive attitude of the farmers and the planers. The momentum in tractorization has, however, been gained during the last few years. Tractor plants, both in the public and private sectors are being established for the production of tractors within the country.

Planning and development in the field of tractors and implements must not be carried out on the basis of speculations of a *few* individuals or the secondary information collected through interviews and surveys only. Primary information on equipment such as laboratory and field performance, technical suitability and economic feasibility is usually needed for developing an appropriate mechanization strategy. Some of the information in this regard has been gathered through research studies at the University of Agriculture, Faisalabad on different agricultural equipment, as mentioned below which may be considered for evolving an appropriate planning and development programme relating to agricultural mechanization.

TRACTORS

a) *Power as an indicator for planning*

Power or level of energy available on our farms may be considered an indicator for planning our future programme of tractors. Power available from different modes is as follows:

Mode of power	H. P. capacity	Population	Power available in H. P.
1. Tractors	50.0	1,30,000	6.50×10^6
2. Work animals	0.5	8×10^6	4.00×10^6
3. Human labour	0.1	13.64×10^6	1.36×10^6
	Total power available :		11.86×10^6
	Area under cultivation :		21.00×10^6 hectares
	Power per hectare :		0.56 H.P.

According to Giles (1967) a range of 0.5 to 0.7 H. P. per hectare is the optimum requirement of power for agricultural production. The power presently available in Pakistan is 0.56 H. P., as mentioned above, which appears to be within the optimum limits prescribed by Giles (1967). Such a figure is mislead.

ing since we have not yet received our optimum level of agricultural production comparable with those of U.A.R., Taiwan and others. Giles (1967) ignored the fact that animals and human labour which contribute to about 50% of the total powder, are inefficient as compared to tractors. Again, one third of the tractors available in Pakistan, are used for haulage and transportation. Further, there is competition between human labour and animal population in the consumption of agricultural produce. It may be added that Giles calculated the optimum figure from a semi log graph plotted between yield per acre and H. P. per acre for different countries. The graph deflected at a point of 0.2 to 0.3 H. P. per acre or 0.5 to 0.7 H. P. per hectare. This was considered by Giles as the optimum limit. This was a wrong conclusion, since the graph must have been drawn on a rectangular graph paper to determine the optimum level. A linear relationship between the yields and H. P. has been determined (from Giles data) indicating thereby, no optimal point. It may be concluded, therefore, that the figure as suggested by Giles, is not a reliable indicator for planning.

b) *Planning on the basis of area*

As mentioned above, Giles basis of 0.5 H. P./hectare does not provide the sound basis for achieving optimum yields. The field capacity of the power units may be considered as another basis for future planning. A tractor can command an area of 30 to 40 hectares (75 to 100 acres). In the existing situation, tractors alongwith bullocks may provide a formula for future mechanization. A pair of bullocks can command an area of 1½ hectare (4 acres). With these considerations, the requirment of tractors may be worked out as follows:-

Population of bullocks in pairs	=	4×10^6
Field of capacity of a pair of bullocks	=	1.5 hectare.
Area commanded by bullocks	=	$(4 \times 10^6) \times 1.5 = 6 \times 10^6$ hectares
Total area under cultivation	=	21×10^6 hectares
Area to be commanded by tractor	=	$21 \times 10^6 - 6 \times 10^6 = 15 \times 10^6$ hectares
Field capacity of tractor	=	40 hectares (average)
No. of tractors required	=	$\frac{15 \times 10^6 \text{ hectares}}{40 \text{ hectares}} = 375{,}000$

Keeping in view the tractor requirement, as calculated above, a systematic programme for increasing its population may be followed. Tractors may be added at the rate of 15% per year in the existing population with a deletion rate of 10% per year due to depreciation.

SMALL TRACTORS

Because of small size of land holdings, arguments have been frequently advanced in favour of small sized tractors of about 10 H. P. for general use in Pakistan. Technically speaking, there does not exist a direct relationship between the size of tractor and the size of holding. In other words, a small size farm does not indicate that a small size tractor be used. On the other hand, a relationship does exist between the depth of ploughing and the size (H.P.) of tractors. Such a relationship has been established as curvilinear. It means that with the increase in depth of ploughing, power requirement increases suddenly. A small size tractor of 10 H. P. is limited in its power capacity and cannot penetrate beyound a certain depth. Further, in the plains of Pakistan, during hot summer days, the conditions are so dry that even the last traces of moisture from soil are pulled out by sun. During monsoon season, when most of the rain occurs in a short period followed by tortuous bright sun, the wet soil becomes so hard that it behaves like concrete. A small size tractor of (10 H. P.) will not be suitable for breaking such a hard soil. Experimental investigation at the University of Agriculture. Faisalabad, have clearly indicated that a small tractor or a power tiller (10 H. P.) is economically infeasible, since its operating cost is 2½ times the cost of a general purpose tractor of about 50 H. P.

The establishment of a plant for manufacturing small size tractors of 10 H. P. in Pakistan should not be considered at this stage. As said earlier, the tractor plant requires huge investment. The resources of the country should not be wasted in producing a tractor of a size which is not acceptable from the stand point of technical and economic considerations. Our tractor industry is still in its primitive phase of development and only those sizes of tractors should be produced which have established their acceptance amongst the farmers and experts over the last many years. However, a small number of power tillers or garden tractors may be imported for trials under rice cultivation.

When the tractor plants have been stabilized in the country, efforts may be made for the production of medium size tractors of 25-30 H.P., provided that the existing manufacturing plants can be adjusted accordinly and that the parts can be interchanged between the tractors of 50 and 30 H. P. sizes.

IMPLEMENTS

Tillage operations are generally performed to break up and pulverize the soil, and to allow the free movement of air and water in order to promote plant growth. Excessive pulverization by means of heavy equipment is, however, detrimental to soil structure. Further, such an equipment may produce soil compaction that could greatly upset the balance between the air, water and solid components of soil. The amount of manipulation of soil or the extent to which tillage should be conducted for the purpose of effective plant growth is a matter of great importance.

Tillage requires maximum energy amongst all agricultural operations. Consequently, it is the most expensive operation in agriculture. At present, about 130,000 tractors are used in Pakistan. With an annual use of tractor for 350 hours in tillage and assuming an hourly consumption of a gallon (4½ litres) of diesel oil (Rs. 18/- per gallon), the total cost of fuel incurred annually on tillage in the country, has been estimated as 820 million rupees. In this age of energy crisis, therefore, utmost care must be exercised in the selection and use of tillage implements with a view to minimize foreign exchange spent on fuel.

Conventionally, our farmer uses a single tillage implement, that is, a narrow tine cultivator for all types of tillage operations. The construction of the implement is such that it skips untilled soil between the tools and thus necessitates greater number of plowings for achieving a suitable seed-bed. This increases the expenditure on fuel, in addition to producing unnecessary soil compaction at a certain soil depth which impedes root development.

In view of the heavy expenditure incurred on fuel in tillage and the hampering effects of excessive tillage on soil structure, minimum tillage has become imperative in this age. In order to except the benefits of the minimum tillage concept, a study of 4-year duration was conducted at the University of Agriculture, Faisalabad. Tillage experiments were conducted on sandy loam,

loam and silty clay loam soil for wheat and maize crops. Tractor drawn implements like mouldboard plow, disk plow subsoiler, narrow tine cultivator, disk harrow, etc., were used. The effects of tillage operations were studied in terms of soil density, moisture, soil resistance, shear strength and yield of crop. The costs of tillage operations and crop production with their economic returns were also determined. The study indicated that narrow tine cultivator and our conventional practice of plowing several times could not prove their worth in the light of the soil, crop and cost parameters considered in the study. It was inferred that excessive plowing be avoided and the use of narrow tine cultivator be restricted. Sweep cultivator was instead considered a better substitute of the narrow tine cultivator. Disk harrow performed best with respect to soil tilth, crop yield and cost of crop production. However, its higher initial cost and manufacturing complexity are the major constraints discouraging its large scale production and use. Further, heavy implements like mouldboard and disk plow had favourable effects on soil characteristics, when followed by disk harrow and sweep cultivator. Their use may, however, be avoided due to their high cost of operation.

PLANTING EQUIPMENT

a) *Grain drills*

Research experiments were conducted for determining the optimum depth of planting and soil impedence for a particular soil and wheat crop. The relevant values of the optimum depth for planting wheat seeds (AU 26) and soil resistance, as determined with the help of a computer programme, were found to be 5.5 cm and 5320 Newtons/Meter^2 (0.76 psi). A range of optimum values for planting crops and soils may be determined using the approach followed in these investigations. Such an information may then be used for incorporating adjustable type furrow openers in the planting equipment for placing seeds and developing proper press wheels for effecting suitable compection pressure in order to ensure optimum emergence of seedlings.

b) *Transplanters*

Korean transplanters were imported a few years ago for adaptation. The machines were used in the various districts of the Punjab by a team of experts of the Department of Agriculture, Government of the Punjab and the University of Agriculture, Faisalabad. The machine was also modified by Korea experts. The following observations were made :

1. The machine originally transplanted 3-11 seedlings per hill as against our requirements of 1-3 seedlings per hill. Consequently, the machines were modified by the joint efforts of Korean and local experts after making changes in their various components. After modifications, the machine transplanted 3-4 seedlings per hill.
2. The machine was not economically feasible, because of the following reasons:
   a) Extra labour was required for pulling, trimming and dressing of wet seedlings, before they could be used by the machine. Further, the machine itself required a considerable labour for its operations.
   b) The cost of transplanting with the machine was about $2\frac{1}{2}$ times the cost with manual operations.
   c) In our conventional practice, 50,000 seedlings are transplanted by hand in one acre of land. With machine operation, about 240,000 seedlings are transplanted per acre (3 seedlings per hill in 80,000 hills). For preparing a nursery of such a quantity the labour increased to 3 times.
   d) Yield did not increase although the number of seedlings transplanted by the machine increased to 5 times. It seems logical, since with the increasing of planting density, the nutrients are not available to all the plants in the same area.
   e) Since the cost of operation with the machine is about 2 times the cost with manual operation, it is a labour engaging rather than a labour displacing equipment.

Although the machine was made to operate satisfactorily after making necessary modifications, it turned out to be economically infeasible due to its high cost of operation and with no increase in yield. It has been realized that the Korean machine may be useful, provided that the farming practices similar to those adopted in Korea such as the use of dry nursery, levelled fields, appropriate irrigation and fertilizer practices, and other biological conditions are maintained in Pakistan.

HARVESTING EQUIPMENT

With the introduction of Augustini Reaper Binders (Italian made) by Millat Tractors, efforts to produce reapers locally achieved momentum. The process of local production has been further accelerated due to the rising trend of the farmers to use harvesters/reapers since at the time of harvesting, weather has become unreliable during the last few years and that labour is not easily available for cutting and collecting the crop.

The studies conducted at the University of Agriculture, Faisalabad showed that harvesting losses increased with time, ranging from 3% in the first week to 7% in the third week, affect the ripening of crop, indicating that a delay of 2 weeks in harvesting can seriouly after crop yield. Further, grain losses from the conventional winnowing operations were higher than those with mechanical thresher and decreased in a nonlinear fashion with distance, becoming negligible beyond a distance of 2.50 meters. With mechanical threshers, the grain losses ranged from 2% to 6% with different locally manufactured threshers. The cost of harvesting with reaper/binder and mechanical thresher is half that of harvesting with manual labour and threshing with bullocks and flail. Mechanical harvesting and threshing required 4 hours as against 48 man/bullock hours.

Reapers have gone into production and are being studied for their performance. The following types of reapers may be considered for production and use :

a) P. T. O. driven, front mounted
b) P. T. O. driven, rear side mounted
c) Self propelled front mounted

P. T. O. driven reapers usually involve breakage of parts due to excessive vibrations. With front mounted machines, cutting operation cannot be observed clearly by the operator. Such a machine also involves dangers due to transmission of power from P. T. C. shaft to the front side of the tractor through a propeller shaft. Safety guards must, therefore, be provided. Rear side mounted reapers have the advantage of better visibility of the cutting operation, but require clearing of some of the area by hand before its operation. Self propelled reapers are expensive but have greater efficiency and involve less breakage of parts.

SOIL, PLANT AND EQUIPMENT RELATIONSHIP

The forces resulting from the application of mechanical equipment, such as tillage and traction devices, affect the resistance of soil. Tillage is generally performed to fragment the soil, weaken soil strength, reduce compaction, and allow free movement of air and water in order to promote plant growth. Traffic by wheel and crawler tractors, on the other hand, causes soil compaction, which increases the resistance or physical impedance of soil and reduces soil's permeability to water and air. All of these factors may affect the quality and quantity of crops grown on the soil. Extensive investigations have yet to be carried out to describe the condition of soil conducive to plant growth in physical, mathematical, and engineering terms. Relationship need to be established between the emergence of plants and the conditions of soil, as affected by the force resulting from the application of the mechanical equipment. Optimum conditions of soil remain to be determined so that machine operations are carried out at proper times. All of this information is needed as a basis for the development of farm equipment and their operation at proper times in order to enhance plant production.

The resistance of soil brought about by mechanical equipment is of great importance in understanding the soil-machine-crop complex. The study of soil resistance would help the engineers in developing proper equipment and practices that would apply proper forces and create favourable conditions for the growth of crops. Accordingly, a study was undertaken of establish relationships between the resistance of soil and the emergence of seedlings for different levels of soil moiture, density and planting depth. The effect of different implements was also studied. It was observed that at different moistures, the soil resistance increased and the emergence decreased linearly with the density of soil. Further, the soil resistance increased and the emergence decreased in a nonlinear fashion with the depth of planting. Further, different types of implements produced different soil resistance which subsequently affected the emergence of seedlings. For example a wheat seedling encountered minimum resistance when soil was prepared with disk harrow, resulting thereby, in an increased growth of crop. Concequently, an understanding of the relationship between soil, crop and equipment is necessary for developing appropriate farm equipment that may be operated at appropriate times in order to create suitable soil environment and thus enhance plant prodnction.

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