Tarım Makinaları Bilimi Dergisi (Journal of Agricultural Machinery Science)
2012, 8 (4), 353-364

Controlled Traffic Farming and Wide Span Tractors

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Received (Geliş Tarihi): 30.03.2011 Accepted (Kabul Tarihi): 12.05.2011

Abstract: Plants require a relatively mechanically weak, open soil condition, conducive to easy and extensive root development, good aeration and water supply, when subsurface drainage is satisfactory. Conversely, much more compact conditions are desirable for good traction and the support of wheels and tracks. There are three primary ways of reducing the overall compaction of field soils by agricultural vehicles: (1) Reduction of the number of passes of conventional machinery, (2) Reduction of the vehicle mass and the contact pressure of wheel systems. (3) Confinement of the traffic to permanent or temporary wheel tracks (controlled traffic). The objectives of this study are: to define the optimum soil compaction, to explain the effects of excessive soil compaction on plant growth and soil physical conditions; to examine the methods of preventing and reducing of excessive soil compaction hazards; to present the the application of wide span tractor.
Keywords: Gantry system, wide span tractor, controlled traffic, soil compaction

Trafik Kontrollü Tarım ve Geniş İz Aralıklı Traktörler

Özet: Bitkiler, toprak altı drenajı tatmin edici olduğunda, mekanik olarak nispeten zayıf yapıda, yoğun ve kolay kök gelişmesini teşvik eden, su temini ve havalanması iyi olan toprak ister. Bunun aksine, tekerlek veya palete sağlam dayanak sağlamak ve iyi bir çeki için daha sıkı zemin koşulları istenir. Tarla toprağının sıkışmasını azaltmak için başlıca üç yöntem vardır. Bunlar: (1) Geleneksel makinelerin geçiş sayısını azaltmak, (2) Taşıt ağırlığını ve tekerlek sistemlerinin temas basınçlarını düşürmek, (3) Tarla trafiğini, sabit veya geçici tekerlek izlerine hapsetmek (Kontrollü trafik). Bu çalışmanın amacı, optimum toprak sıkışmasını tanımlamak, aşırı toprak sıkışmasının bitki büyümesine ve toprağın fiziksel özelliklerine etkisini açıklamak, aşırı toprak sıkışmasının oluşturduğu zararları önleme veya azaltma yöntemlerini ortaya koymak, geniş iz aralıklı traktör uygulamasını tanıtmaktır.
Anahtar kelimeler: Gantry system, geniş iz aralıklı traktör, kontrollü trafik, toprak sıkışması

INTRODUCTION

Most agricultural field operations result in soil loosening or compaction. In mechanized agriculture, intensive traffic with tractors and other heavy vehicles leads to soil compaction that strongly influences soil properties and processes. The compaction may greatly affect plant growth as well as production costs and environmental effects of crop production, and it has far-reaching economic implications. Over the past few decades, soil compaction in the top soil has been identified as one factor limiting further increases in cropping efficiency (Figure 1). The opportunities for reducing the mass of farm machinery have been under consideration for many years. Although this idea was adopted, the demand for greater power and complexity of operation during the past 20 to 30 years has given rise to machines three or four times heavier than the early tractors.

On arable land, the structure of the topsoil and the subsoil is often damaged as a result of frequent traffic with heavy machine and transport vehicles, which exert high specific ground pressures because their wheels have to support high axle loads. The damage caused by wheel pressure becomes even worse when tillage and traffic on wet soil is not avoided and, partly, when the soil does not contain sufficient amounts of humus and calcium carbonate.

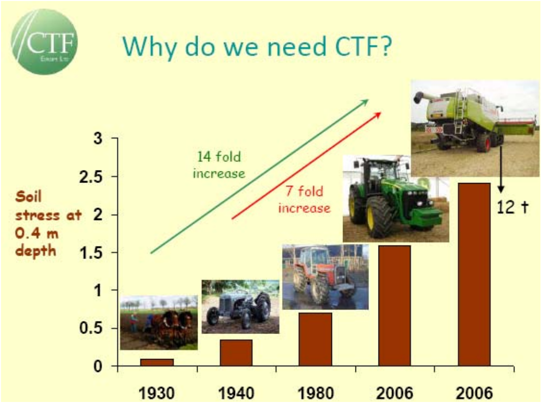

Figure 1. The necessity of controlled traffic farming

It has also been recognized that a complete absence of soil firming may lead to a reduction in crop performance due to nutrient deficiencies and that a certain degree of soil compactness is required for maximum seedling emergence and crop yield (Önal, 1971; Önal, 2003)). This optimum level of compaction impedes the movement of liquids and gases within the rooting zone, through a reduction in soil porosity, and its alleviation requires a regular, energy-intensive, deep loosening operation to sustain crop yield. Several parameters have been used for characterizing the state of soil compactness, such as dry bulk density or total porosity, air-field porosity at a certain matric water tension, penetration resistance or soil strength. None of these, however, can be directly used to compare the state of compactness of different soils. Because compaction and loosening are processes that are characterized by volume changes, it seems most appropriate to use methods based on volumetric relationships, preferably on commonly used soil parameters such as dry bulk density or porosity. However, these parameters vary between soils and have limited value when different soils are compared. A bulk density which indicates an extremely compact state in one soil may imply a very loose state in another. The "degree of compactness" has been shown by Ha'kansson (1990) to be a more useful measure than bulk density or porosity in relation to crop performance, because the maximum yield is obtained at a very similar degree of compactness, regardless of soil type.

THE DEGREE OF COMPACTNESS

The "degree of compactness (D) expressed in percent" defined as the relative bulk density of a field soil compared with the density acquired by a soil subjected to a static pressure of 200 kPa:

$$D = {}^{100 \cdot \rho_d}\!\big/_{\rho_{d.p}} \qquad (1)$$

where ρ_d is the dry bulk density of the soil and $\rho_{d.p}$ is the dry bulk density of the same soil in the reference state. This state is the densest state that can be obtained by a static pressure of 200 kPa (2 bar). The "degree of compactness" quotient was independent of soil characteristics although yield responses on fine-textured soils tended to be more sensitive than those on coarse-textured soils. The optimum degree of compactness tended to be high in years with a dry growing season and low (no need for recompaction) in years with a rainy growing season. The mean optimal degree of compactness for barley is shown in Figure 2.

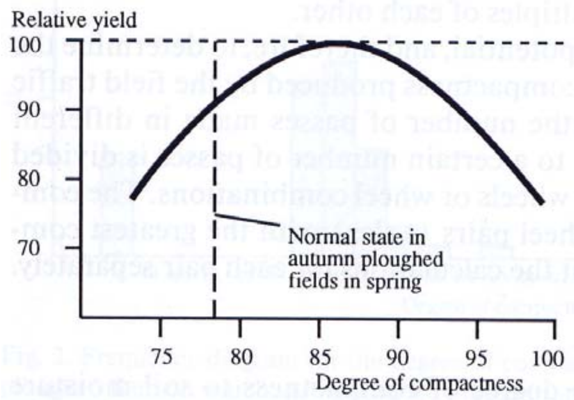

Figure 2. General relationship between degree of compactness and yield (Arvidsson & Ha'kansson, 1991)

The optimal value has also different between crop species: barley, wheat and sugar beet have required the highest degree of compactness and potatoes the lowest; oats, peas, and rape have required intermediate levels. The seasonal change in the optimum "degree of compactness" for yield of cereals was chosen by Eriksson et al. (1974). The mean optimum degree of compactness for spring sown cereals was generally between 85 and 90%. For winter cereals the mean optimum value was between 78 and 84%. In an extensive series of measurements the effects of various factors associated with tractor traffic in the spring on the degree of compactness in the plow layer were established by Ljungars (1977). Among the factors studied, soil moisture content, number of passes and wheel equipment were of greatest importance, whereas tractive power and speed had very little influence on the degree of soil compactness. Inflation pressure in the tyres and weight of the machinery were of intermediate importance.

EFFECTS OF TRAFFIC COMPACTION ON THE YIELD AND PLANT GROWTH

In a field trials on sandy-loam soil, studies were made into the effect of wheel pressure in traffic lanes caused by field operations involved in rotational cropping over two growing seasons (1982, 1983) when vehicles passed these traffic lanes a total of 26 times (Petelkau & Dannowski, 1990). The studies were carried out at three different load stages (mean contact pressure/maximum wheel load): (I) 100 kPa/17 kN; (II) 300 kPa/34 kN; (III) 500 kPa/34 kN. In 1984, the residual effect of vehicle traffic was studied in oats that were grown uniformly over the whole width of the field as a test crop. In contrast to non-tracked ground, grain yields declined in the traffic lanes at load stages I, II and III by 3.6, 26.0 and 28.3%, respectively. Nutrient uptake (N, P, K, Ca, Mg) by the plants grown in traffic lanes was reduced accordingly. Wheel-induced compaction in former traffic lane areas was clearly evident from measured values of bulk density, pneumatic conductivity, penetration resistance and rootability of the soil.

Van de Zande (1991), defined the traffic intensity as a total area that comes into contact with wheels per hectare of cropped land per year. The wheeled area varies with crop type and farm size, owing to differences in the mechanization. Traffic intensity, or the number of times total coverage of the arable field with ruts occurs, varies between 5.4 ha ha^{-1} $year^{-1}$ for a potato crop (farm sizes < 35 ha) and 2.2 ha ha^{-1} $year^{-1}$ for winter wheat (farm sizes between 55 and 80 ha). Considering the average crop rotation occurring on the farms, traffic intensity decreased from 3.9 ha ha^{-1} $year^{-1}$ (farm sizes < 35 ha) to 3.2 ha ha^{-1} $year^{-1}$ (farms > 80 ha). Sommer et al. (2001) indicated that repeated compaction on the same tract width increases the strength of soil and soil compaction hazards.

Crop yield loses can be estimated from traffic intensity in Mg km ha^{-1} $year^{-1}$ (Mg km is the product of the weight of the machine and the distance driven), soil moisture content, tyre inflation pressure and clay content. A large number of trials have been conducted, in which the ground was trafficked by vehicles of moderate axle load every autumn prior to mouldboard plowing. A summary of the results from plots with a traffic intensity of 350 Mg km ha^{-1} is shown in Figure 3. (Arvidsson & Ha'kansson, 1991).

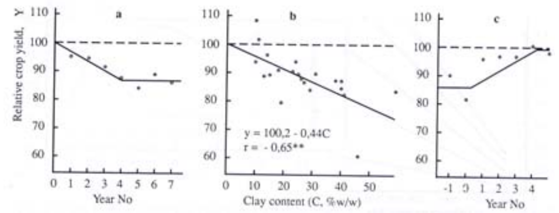

Figure 3. Results of a series of long-term field trials in which the topsoil was annually compacted by traffic with tractor and wagon prior to plowing. The diagrams show yields obtained in compacted plots, expressed as percent of the yields in uncompacted plots. (a) Mean yield for the first 7 years after start of experimental traffic. (b) Yield expressed as a function of clay content. Every ring corresponds to one study site. (c) Mean yield after termination of the experimental traffic (Arvidsson & Ha'kansson, 1991)

From Figure 3 it can be concluded that the yield decreased from year to year by repeated compaction experiments during the first few years, after five years it reached an equilibrium. There was a highly significant correlation between clay content and yield reduction. The effects on crop yield were proportional to the traffic intensity in Mg km ha^{-1}.

Field observations in the vicinity of wheel tracks have shown that root penetration may be seriously retarded (Voorhees, 1977). In contrast, root growth on soils of low bulk density tends to be relatively unbranched which may result in sub-optimal exploration of the soil and hence deficiences of some macro-and minor-nutrients. Eriksson et al. (1974) reported that the root growth of wheat seedlings was progressively reduced when the soil was subjected to surface pressure in excess of 200 kPa and the limiting penetration resistance for root growth was reported to be between 0.8 MPa and 5 Mpa. The yields of non-cereals are generally more sensitive to compaction than those of cereals. Many experiments have shown that crop yields decrease as the strength of soil layers or volumes increase. In an irrigation experiment, Carter et al. (1965) found that seed cotton yield decreased linearly from 3600 kg ha^{-1} where penetrometer resistance measured at "field capacity" (cone penetrometer) was 0.3 MPa to 1450 kg ha^{-1} where resistance was 4.0 Mpa (40 kg cm^{-2}) (Figure 4). Cotton rows in which wheels passed on both sides yielded less than those which received traffic on one side only. However, as with cereals, soil water status can influence this response.

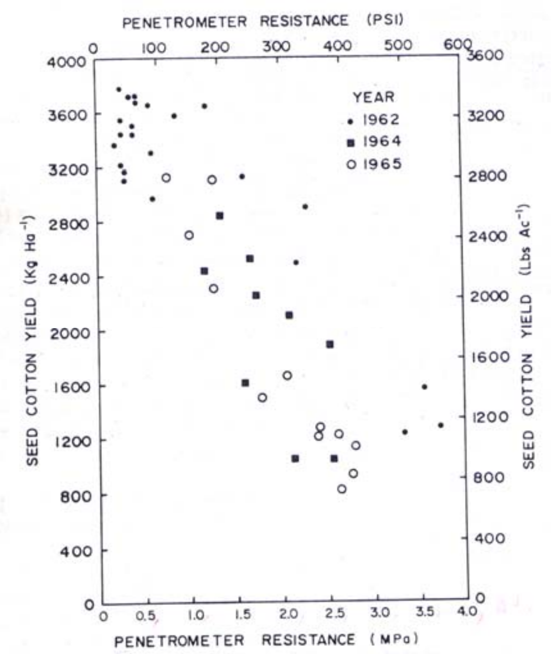

Figure 4. Relationship between penetrometer resistance and yield of seed cotton (Arkin &Taylor, 1981)

For example, Voorhees (1977) found that in Minnesota during years when precipitation was less than normal, the yield soya-beans was 25% higher where wheel traffic had occurred on both sides of the row than where it had occurred on one side only. However, he found a 35% reduction in the yield of potatoes as a result of wheel traffic. Small seeded crops such as onions (*allium cepa L.*) are more easily mechanically impeded than crops such as cotton and grain sorghum (Taylor et al., 1966).

REDUCING THE OVERALL COMPACTION OF FIELD SOILS BY AGRICULTURAL VEHICLES

The annual losses in crop yields due to soil compaction in Sweden have been reported to be worth about Skr 80 million (Eriksson et al., 1974) while in the U.S.A. the corresponding figure is $1180 million (Gill, 1971). Yield reduction will vary with respect to location, season, soil type and crop. The most serious losses can be expected with non-cereals grown under irrigation. Sheesley and Grimes (1077) calculated that comparatively minor modifications to the wheel traffic patterns in Lucerne fields in California could result in an increased annual income of about $ 63 million per annum or $ 157/ha for the farmers concerned.

There are three primary ways of reducing the overall compaction of field soils by agricultural vehicles:

1. Reduction of the number of passes of conventional machinery,
2. Reduction of the vehicle mass and the contact pressure of wheel systems.
3. Confinement of the traffic to permanent of temporary wheel tracks (controlled traffic).

A diagrammatic representation of these options in relation to the types of vehicles is shown in Figure.5.

CONTROLLED TRAFFIC, PERMANENT TRACKS

Efficient and profitable crop production is dependent upon achieving appropriate soil conditions for both the crop and associated machinery operations. Unfortunately, the optimum conditions required for crop growth are very different to those required for efficient trafficking.

The concept of controlled traffic is not new. In this technique, certain narrow strips of the field are set aside for all of the vehicular tire traffic. These areas often become so compact and have such high strength that no plant roots in the surface soil horizons. Consequently, the water and fertilizer nutrients in these soil volumes are not available to crops (Trouse et al., 1975). In all soil volumes not compressed by tire traffic, water and nutrients are freely available. In a 3-year study on a Norfolk loamy sand soil in Alabama, Young and Browning (1977) found that seed cotton yields averaged 2335 kg ha^{-1} when tractors and sprayers were not controlled to traffic strips and 2540 kg ha^{-1} when controlled to strips. Even though controlled traffic increased infiltration of irrigation water in California, cotton yields did not increase in the San Joaquin Valley (Chancellor, 1976).

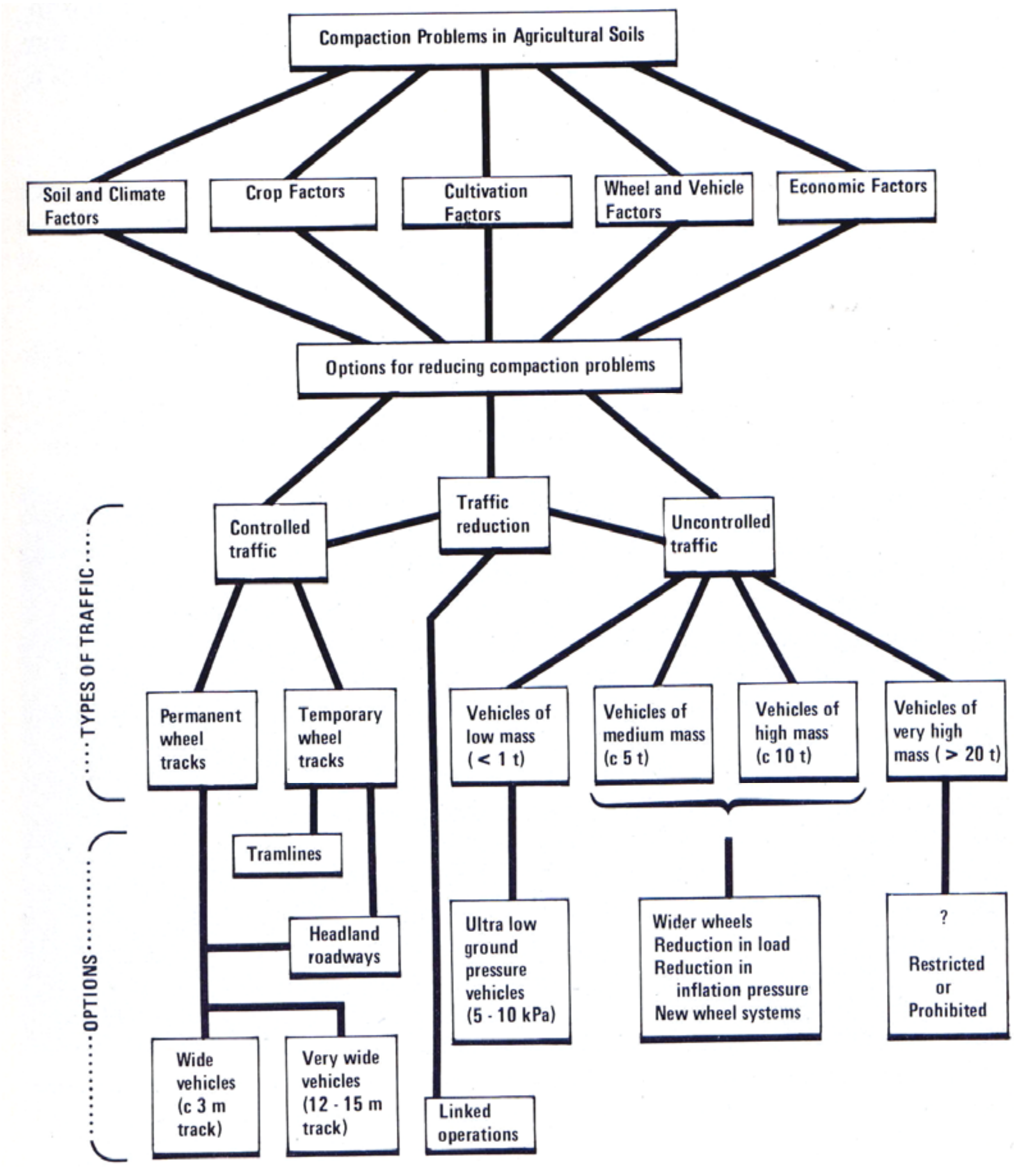

Figure 5. A simplified diagrammatic representation of some of the options available for reducing compaction in relation to the factors affecting the cultivation system as a whole (Soane et al, 1979)

Towards the end of the 19th century, winch-operated plows and other cultivation implements were widely used with steam traction engines which, due to their considerable mass (about 15-20 t) and poor manoeuvrability, were confined to the headlands. Some farmers insist on that combine harvesters discharge grain headlands, thus eliminating trailer traffic from the field. The tramlining of sowing and spraying traffic in cereals has resulted in greater uniformity of crop in the zones free of traffic but the wheel tracks created are essentially temporary, being destroyed by subsequent cultivation for the next crop.

Figure 6. Tramlining of sowing and spraying traffic in cereals

Permanent tracks: Under conventional systems of management, traffic is random, with wheels compacting much of the land. During any one operation 15-55% of the land was covered by tracks depending on the implement used. One of the main aims of tillage is to undo this damage, but tillage may simply fill in the ruts, without loosening the compacted soil beneath. The strength of the soil in the permanent tracks was five times greater, and allowed better traction, than that of conventionally tilled soil on flat land (Tulberg, 1986). However, in the uncompacted ridges between the tracks, the strength of the soil was 30% less than in tilled soil on flat land. Also less energy and 30% less tractor power were needed to sow crops. Infiltration rate was more than six times higher, and the yield of barley, sorghum or soybeans grown on the uncompacted ridges was 15% higher, than in tilled soil on flat land.

The permanent bed system of crop production, which has long been used in certain vegetable and fruit crops, is now being examined experimentally for large scale agricultural crops (Figure 7). Market improvements in soil conditions and cotton yields were obtained at the US National Tillage Machinery Laboratory (Cooper et al., 1969; Dumas et al., 1974). Increases in yield of several crops have been found with zero levels of post-planting traffic. For instance, Raghavan et al. (1978) found that the average yield of silage maize in zero-traffic plots was 30% higher than yields with standard commercial management. Controlled traffic may have particular significance under reduced tillage systems. The yield of soya beans was increased by 16% where traffic was eliminated on deep plowed plots but by 25% on shallow cultivated plots (Gill & Trouse, 1972).

Harvesting controlled traffic plots may present problems. Colvin (1976) described techniques for applying varying amounts of traffic over a number of years to maize (corn) grown in 770 mm row spacing. To permit the wheel traffic treatments to be harvested without interference from the combine wheel tracks maize combines with 3, 5 and 7 row head frames had to be used. Evidence for the potential benefits of controlled traffic in potatoes has been given by Soane (1975). In the first year of the study yield increases of 24% were reported for the zero-traffic treatments. Field machines with working widths much in excess of 3 m, encounter severe problems on public and farm roads and through gateways. However, a suitable wheel system would allow the machine to run longitudinally on roads and headlands and laterally in the field. Such a machine has been described by Rutherford (1979) and a design for an advanced multi-purpose vehicle with a 12-m track width operated from a 100-150 kW power unit has been set out by Chamen et al. (1994).

Figure 7. Controlled traffic application by onion (top) and wheat growing (bottom)

Where rows are maintained in the same place each year, as with ridges, certain cultural practices like "controlled traffic" which are not practical when using full-width (random traffic) tillage systems can be used. Keeping wheel traffic off the row area is strongly recommended in a ridge system since equipment tires operated on ridges during or after harvest, and before spring planting, can deform ridges and create planting problems. Ridge tillage are requires approximately 60% less fuel than a conventional fall moldboard plow tillage system (Stone et al., 1990; Önal, 1984). However, ridge tillage requires a specialized line of equipment, restricts growers to corn-soybean rotations and it has not been widely accepted on the clay and clay-loam soils. Concentrating wheel traffic in the fewest possible row middles (for all the various field operations performed) may also be desirable. Corn root studies have shown greatly increased rooting volume in untrafficked zones.

Planting crops on ridges is not a new idea. Ridge tillage or "till-planting" as currently practiced in the Corn Belt is defined by the Conservation Technology

Information Center as "a form of conservation tillage in which the soil left undisturbed prior to planting. Cultivation is used to build ridges. A very specific sequence of operations includes the following: (1) ridges are normally formed in corn or soya bean fields at last cultivation; (2) no further tillage is done until planting the following spring; (3) ridge scrapers, mounted ahead of planter units push old-crop residue and some soil to row middles (Figure 8); (4) seed is planted with one spring operation into the residue-free, moist soil cleared by the scrapers.; (5) ridges are again reshaped at last cultivation and the cycle is repeated. Although not a major tillage system for row crop production in the USA, (960 000 ha in 1988), use of the system is growing rapidly in the Corn Belt (Griffith et al., 1990). About 66% of all irrigated land in Texas is on the High Plains, and about 60% of that land is furrow irrigated (ridge tilled). Furrow irrigation is used on about 90% of the slowly permeable soils that are irrigated on the Texas High Plains (slop usually less than1%).

Early soil warm up, reduced costs, erosion control, better timeliness, controlled traffic and energy saving are the advantages of ridging. Special equipment is needed to make and reshape ridges at last cultivation and to scrape the ridge tops ahead of planter units (Figure 9, 10). Wheel spacing and tire sizes of tractors and other production and harvesting equipment that traffic ridged fields also need attention. Ridge shaping attachments can be mounted directly to the planter frame, on separate toolbars attached to the planter, or on toolbars separate from the planter.

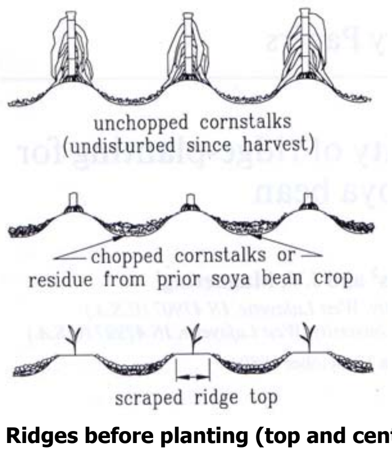

Figure 8. Ridges before planting (top and center) and with crop emerged a few weeks after planting (bottom) (Griffith et al., 1990)

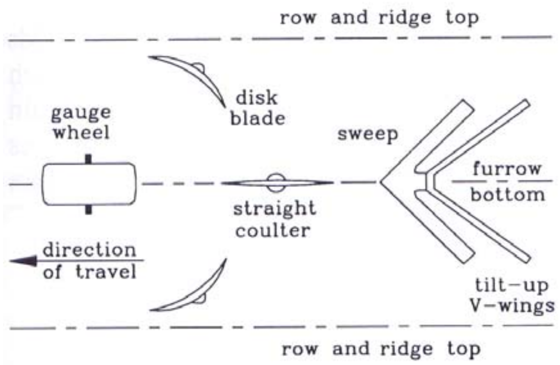

Figure 9. Component arrangement (top view) for "ridge type" cultivator gang (Griffith et al., 1990)

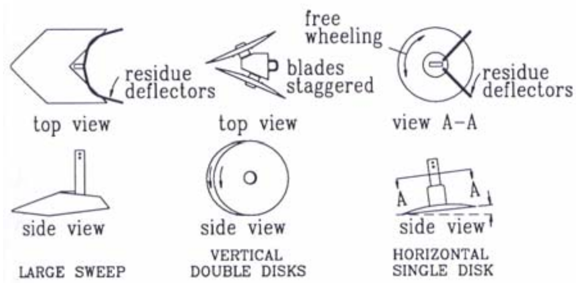

Figure 10. Three types of ridge scrapers commonly used at planting (travel direction to left). (Griffith et al., 1990)

Permanent tracks avoid compaction of the soil in ridges and, compared with flat land, lead to higher infiltration, growth and yields, with less energy needed to sow crops. Johnston & Van Doren (1967) gave three zones in relation to miniterraces or permanent ridge-furrow systems: (1) a traffic zone, (2) a water management zone, and (3) a plant zone. The functions of the various zones and their importance vary with different soil and climate conditions. Figure 11 shows the plant, traffic, and water management zones for miniterraces for humid areas (such as the Texas Blacklands). Each furrow carries its own runoff water to a safe outlet. This system is also useful in furrow-irrigated areas (such as the Southern High Plains).

Figure 12 shows the traffic, plant, and water-management zones for miniterraces for dryland agriculture in semi-arid areas where water conservation for plant growth is of utmost importance. This system has improved dryland saline conditions in the Lower Rio Grande Valley. In this system the compacted traffic zone on the ridge serves as a watershed for the plant and water management zone in the furrow. Having the plant and water management zones together in the furrow should have distinct advantages, especially in semiarid regions. It has been suggested that this system can be modified by omitting every other ridge to form a wider level area for the traffic zone.

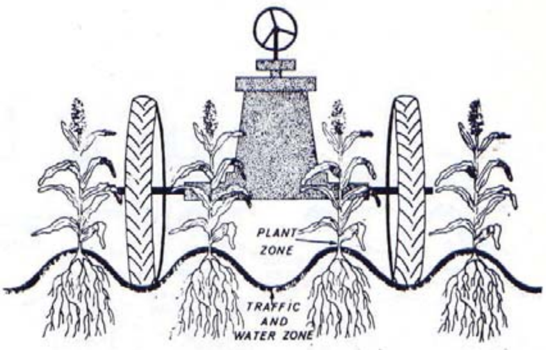

Figure 11. Miniterraces or permanent ridge furrows for humid areas in relation to plant, traffic, and water-management zones (Johnston & Van Doren. 1967)

Lister ridges and furrows have been constructed annually in water–deficient areas. On the contrary, beds and furrows have been used in humid section. Figure 13 shows the application of beds and furrows system at the USDA Great Plains Research Center in Texas. One distinct advantage of this system is that the traffic, water, and plant zones are separate, thus special consideration can be given each in managing the total machine-soil-plant system for maximum benefits.

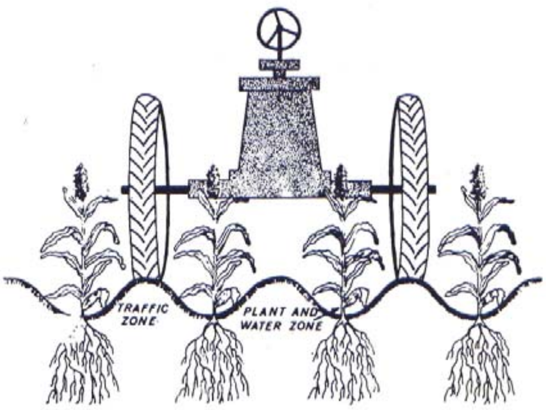

Figure 12. Miniterraces or permanent ridge furrows in relation to traffic, plant, and water-management zones (Johnston & Van Doren. 1967)

This system was conceived for special wide furrow irrigation of grain sorghum and soybeans in 30-in. rows and for primary strip tillage of the water and plant zones only, using a rototiller. Williford (1980) developed an equipment for a system for production of cotton in which all tractor wheel traffic would be restricted to traffic zones. The system consists of growing two rows of cotton, 1 m apart, on a bed or swath width of 2.5 m. and used in the sandy loam soil in Mississippi Delta. This production system gave a higher yield than conventional production plots.

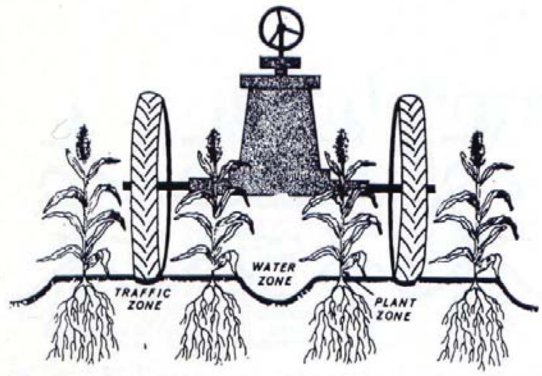

Figure 13. Permanent broad-base ridge and furrow system in relation to traffic, plant, and water-management zones (Johnston & Van Doren. 1967)

Figure 14 illustrates a further possible modification of the beds and furrows system by introducing vertical mulching. 4-in.-wide vertical trenches in inter-row area improve the root development and activity. A soil-mulch trench in the water-management furrow may allow storage of irrigation and rainfall water at greater soil depths and reduce soil water evaporation losses. A plastic tube for subirrigation may be placed in the soil-mulch trench.

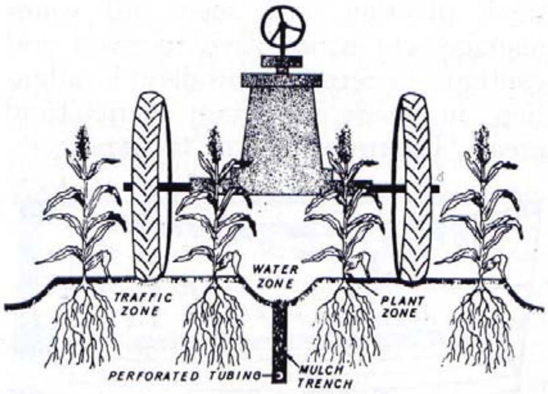

Figure 14. Permanent broad-base ridge and furrow systems in relation to traffic, plant, and water-management zones showing possible use of mulch trenches and subirrigation tubing as additional components of the system (Johnston & Van Doren. 1967)

WIDE SPAN (GANTRY) TRACTORS

Scientists must develop strategies for breaking down some fundamental barriers limiting crop production: (1) The first critical barrier to crop production is the soil compaction.and deteriorated soil structure. The trend over recent years has been towards heavier and more costly tractors with relatively narrow wheel widths. Tractors performing on agricultural soils generally demonstrate low tractive efficiencies because of high rolling resistances and /or slip. To improve tractive efficiency, and consequently energy efficiency, commercial tractor manufacturers have resorted to four-wheel drive arrangements, dual wheels and extra ballast. These effords to improve tractive efficiency, however, has been increased incidence of both soil compaction and deteriorated soil structure. Many studies significantly document reduced crop yields and greater tillage energy requirements where soil is compacted. (2) Another critical barrier to crop productivity is timeliness, especially in drilling and harvesting operations. For example, in the Rio Grande river basin (USA), helicopters have been observed to remove vegetable crops on pallets during wet conditions when tractors and handling equipment could not enter the fields. Even in dry areas, required irrigation can hamper the entrance of tractors into fields on a timely basis.

To overcome limitations imposed on crop production by conventional tractors, some innovative farmers and researchers have widened wheel spans on tractors, built prototype wide-span carrier vehicles or modified mobile irrigation machines (Figure 15).

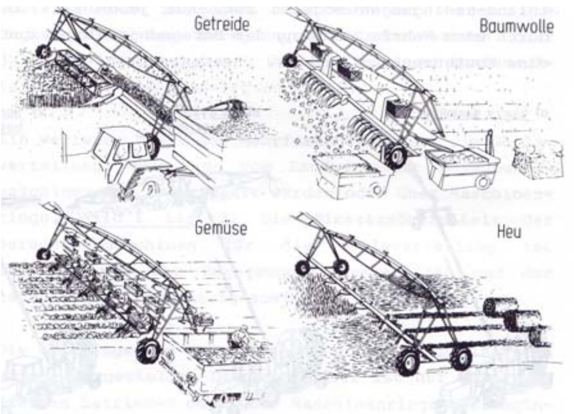

Figure 15. Modified mobile irrigation machine for vegetable harvesting (Sourell et al., 1988)

The new integrated field machine technology target is to overcome the limitations of conventional tractors. This requires the development of a lightweight, overhead mobile agricultural frame with spans in excess of 12 m and clearance sufficient for production of all field crops. Operational functions for cultural practices and harvesting of vegetable crops will be accomplished by tools mounted to the frame through a special mobile hitch arrangement. Orientations of tools may be both parallel and perpendicular to the travel direction of the frame.

Various forms of wide span machines, known as gantries, have been developed for the mechanized production and harvesting of crops ranging from cereals to cauliflowers (Holt, 1989; Manor, 1995). Depending on the application, the reasons for using a gantry instead of more conventional vehicles are some or all of the following:

- Reduced crop damage. This is particularly relevant to the selective harvesting of crops such as cauliflowers or calabrese.
- Reduced soil damage,
- Improved access for harvesting when the soil is very wet. The soil in some of the principal cauliflower growing areas has a low strength when saturated and this, at times, prevents tractor-based harvesting equipment from working.
- Increased work rate due to a greater carrying capacity for materials or produce or workers. A greater working width is possible with operations such as transplanting or crop spraying.
- Improved working conditions provided by an enclosed stable work platform.

Figure 16 shows the principal parts of the experimental gantry designed and constructed by The AFRC Institute of Engineering Research (UK) (Holt & Tillett, 1989). The gantry was designed to span a 9 m wide bed and consists of two 0.5 m wide crawler track units, A, with an overall length of 3 m, supporting a space-frame beam, B. Jack-down wheels, H, are provided at each end of the beam to enable the gantry to be towed by a tractor from field to field and on public roads. To provide flexibility in the materials handling operation, six separate fork lift units, C, using a double parallelogram linkage have been attached to the beam. The beam has a cross-section of 1.33 m wide x0.62 m deep and is fabricated from 50C high yield rectangular hollow section steel.

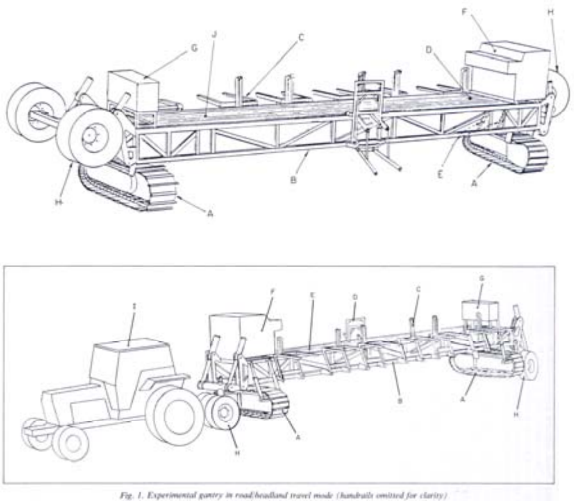

Figure 16. Principal parts of the experimental gantry (top) and transport position (bottom) (Holt & Tillett, 1989).

Figure 17 shows the latest design from Dowler Gantry Systems. Spans of between 5 m and 15 m are offered.

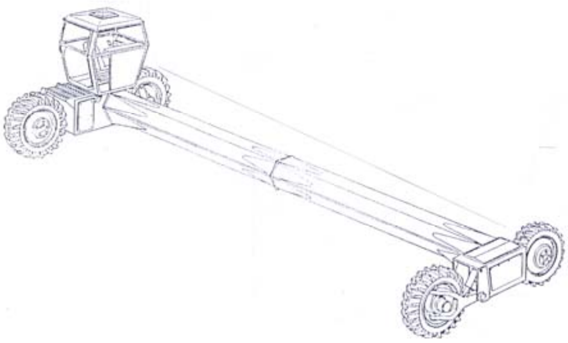

Figure 17. The typical shape and configuration of the latest design of gantry tractor (Chamen, 1997)

Why use a gantry rather than a tractor for traffic control ?:

- Firstly, the gantry marks out fields precisely and automatically without the need for measurement or additional equipment. This means that no under- or over-lap occurs with any operation and no judgement is required by the driver.
- As there is only one wheel mark per implement bout, the land lost to wheelings is minimised compared with a tractor-based system. The differences between the systems indicates a potential 18% increase in cropped area with the gantry, for rows spaced at both 275 and 850 mm. (Tract width of tractor 2.1 m; gantry track width 8.1 m)
- The gantry offers a stable platform from which existing or wider application booms can be supported without the need for suspension systems. Future row and plant scale technology will require precise crop and/or soil engaging components of the machine system. The gantry is ideally placed to offer the platform from which this technology can be applied.
- The wide frame of the gantry provides full width support for implements. This allows savings in implement weight and production costs, while its transport system largely negates the need for heavy and costly folding mechanisms.
- The use of multiple or wider units mounted on the gantry, particularly in vegetable production, could save significantly on labor costs.
- In vegetable production, crop quality and evenness is improved due to fewer wheel passes per unit area. This reduces crop damage both above ground in physical terms and below ground from soil compaction effects.
- In the event that plowing is needed on a regular basis within a completely controlled traffic regime, a gantry can carry out this operation without compromising the system. Thus even with a gantry span of 12 m. plowing can stil be carried out without wheeling the bed.

The Field Power Unit (FPU) made by Ashot Ashkelon in Israel was first commercialised in about 1984. This 5.8 m span, 175 kW four wheel drive vehicle has been used for subsoiling, heavy cultivating, rotary cultivation, planting, spray and fertilizer application, cotton picking and moving. The Dowler gantry was commercially available from 1989 and this 12 m span, 69 kW two wheel drive has been used for light cultivation, power harrowing, cereal and row crop drilling, as well as for spray and fertilizer application.

Gantries have not yet reached the stage of development where all the characteristics can be claimed. The gantry system could be an attractive and healthy alternative for the future.

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