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of the Full Members
(Bologna, 14th-15th November 1999)

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CLUB OF BOLOGNA

PROCEEDINGS
OF THE 10th MEETING
OF THE FULL MEMBERS

Bologna

14th – 15th November 1999

XXX EIMA

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CONCLUSIONS
AND RECOMMENDATIONS

Sixty-five **experts** from 29 **countries**, and representatives from **FAO**, **AIT and UNIDO** convened at the 10th Meeting of the Club of Bologna, organised under the aegis of **CIGR**, in order to examine and discuss the following topics:

1) Development of technologies for the distribution of inputs: livestock slurries, manure, mineral fertilizers and irrigation

2) Transfer of technology from the industrialised to the emerging nations: experiences and results in some countries of Asia and the Far East.

A brief session was also devoted to a discussion on the 2nd updated edition of the **Report on the development of mechanisation** in 28 countries.

The participants unanimously reached the following:

Conclusions and Recommendations

1. Development of technologies for the distribution of inputs: animal slurries, manure, mineral fertilizers and irrigation

This important topic, which has environmental connotations and also touches on precision farming, was discussed on the basis of introductory talks by: F. **Sangiorgi** (Italy), L. **Rodhe** (Sweden), P. **Balsari** (Italy) and E. **Kenig** (Israel). In addition, a written report was contributed by A. M. **El Hossary** (Egypt).

The first three speakers — respectively the authors of key-note reports on the distribution of livestock slurries, manure and mineral fertilizers — cited the legislation in force in their respective countries, and noted a certain delay in the development of modern distribution technologies that are able to meet the following requirements: agronomic exploitation of the various inputs; quality of distribution; conservation of active ingredients; safeguard of the environment (especially air and water). For this reason, in their papers the speakers proposed new solutions geared to drastically improving the distribution performance of existing technologies. In particular: F. **Sangiorgi** described how present-day slurry tanker technology in Italy has fallen behind with respect to The Netherlands, Germany, France, the USA and Sweden, and underlined the need for innovations aimed at: improving the work rate, reducing soil compaction, ensuring good uniformity of distribution with low running costs and minimising environmental pollution, especially through the use of systems for injecting the slurry into the soil. In addition to all this, there is also the need to update the transport regulations and equip the slurry tankers with active electronic controllers and suitable sensors, installed both on board the machines and in the farm centre. L. **Rodhe**, on his part, first of all noted the need to define, at the international level, certain parameters aimed at: verifying the composition of the manure; quantifying the presence of nutrients; evaluating the long term efficiency of the nutrient cycle in the soil. Moreover, he stressed the need — notwithstanding recent advances in prototype slurry tankers in certain European countries (Sweden, France and Germany, in particular) — to promote far-reaching and concerted research activities aimed at developing vehicles which assure highly precise distribution, improved nutrient utilisation and minimise damage to the soil, while at the same time contributing to safeguard the environment. Next, P. **Balsari** recalled the high percentage of nitrogen that is lost by present-day slurry spreaders and therefore not utilised by the crops, and provided a broad overview of the existing technologies, emphasising the need for: in the short term, further developments in electronics and real-time geopositioning systems applied to the machines; in the long term, the development of solutions which permit gradual absorption of the active ingredients, as well as machines with the necessary quality performance for complying with the environmental restrictions that are progressively being adopted in the various countries.

E. **Kenig** gave a detailed overview of the most recent innovatory developments in the field of pressurized irrigation systems, with reference to three types of systems: drippers, micro-jet sprinklers and sprinklers. These developments have brought significant improvements in terms of uniformity of distribution and water conservation, with consequent economic and environmental advantages. Nonetheless, the solutions described are not yet sufficiently widespread or familiar to farmers, and therefore efforts are needed to promote their adoption in both the industrialized and emerging countries. Finally, A.M. **El Hossary** described the modern systems in use in Egypt, which are gradually making headway in the country.

Following an in depth and wide ranging discussion, the participants **acknowledge** the need for a drastic qualitative improvement in the existing technologies in order to give a positive answer to the problems illustrated by the speakers, and which affect both industrialised and emerging nations alike; they **recommend** that every effort be made to rapidly define - based on high common standards - the most appropriate processes and technologies for optimising the agronomic utilisation of the various inputs, for reducing waste and running costs, for improving the quality of distribution and, in consequence, for contributing to the safeguard of the environment. They also **underline** the need to promote, at the policy-making level, the definition and adoption of the new technologies supported by appropriate electronic devices and managed at the territorial level; to promote concerted international research projects and wide-ranging campaigns for demonstrating the advantages which the new technologies can offer over the existing ones, and to support the manufacturers in such activities; to assist in farmer training and the certification of new models; to promote the transfer of effective and appropriate technologies to the emerging countries, thereby enabling them to obtain higher yields without incurring higher costs or damage to the environment. Finally, they **confirm** the necessity of taking a multi-disciplinary approach to the problem -- also encompassing pre-treatment -- in which the spreading machine is just one component used for the rational agronomic exploitation of animal slurries and mineral fertilizers.

2. Transfer of technologies from the industrialised to the emerging countries: experiences and results in Asia and the Far East

This important topic was discussed based on highly informative introductory talks by K.U. **Kim** and G.J. **Chung** (Sout Korea), **Wang** M., **Zhang** L. and **Geng** C. (China), A. **Firodia ,** K.Th. **Renius** and R. **Bacher** (India).

In their presentation, K.U. **Kim** and G.J. **Chung** recalled the considerable evolution which took place in South Korea from 1962 to 1997, when 279,000 agricultural tractors and implements were manufactured in the country, and gave a comprehensive report on the results of the technical cooperation ventures, starting in 1962 with the Japanese company Kubota and subsequently extended to various manufacturers from Japan, Italy, the USA and Germany.

On the strength of these experiences, the speakers asserted that technology transfer needs to be viewed as a commercial transaction that is mutually beneficial to the parties involved. They noted how an effective method for transferring technology is that of assuring a progressive development of the local manufacturing and engineering know-how (with a gradual increase in added value), while supporting this process with appropriate facilities for the development, testing and evaluation of the manufactured machines. In any case, simple technical cooperation agreements have proved inadequate for ensuring acquisition of all the necessary manufacturing technologies. In fact, the problem which arises is the ability of the local manufacturers to fully utilise the imported technologies. Among the various possible forms of technology transfer, the speakers suggest that the best ones are those based on true joint-ventures, renewable on a five-year basis, in which comparable investments are made by both parties, and which provide for an equal apportioning of the profits of the venture.

For the People's Republic of China, **Wang**, **Zhang** and **Geng** provided an informative historical outline of the evolution which took place from 1959 to 1980, a period which saw a progressive and gradually accelerating development of agricultural mechanisation. It was after this period, starting in 1981, that the country began to focus on the creation of joint-ventures with the industrialised countries. In connection with this activity, the authors described the chief problems encountered, mainly concerned with the need to: adjust the internal manufacturing structure in order to provide sufficient capacity for the production of high power tractors; incorporation of local manufacturing units; promotion of research and development activities to support manufacturing; updating of the existing legislation with a view to facilitating the creation of new joint-ventures.

The authors note how, today, cooperative ventures have already been established with the leading international manufacturers (J. Deere, New Holland, Case, Yanmar, Kubota etc.) as well as with manufacturers from South Korea, and reassert that top priority must be given to all forms of technology transfer, promoting them with appropriate laws which, while defending local interests, also facilitate the introduction of foreign companies through: contracts that provide for progressive enhancement of the local added value; creation of applied research centres to serve these new production facilities, including the training of specialised personnel.

A. **Firodia** et Al. then presented the specific case of India, and the positive evolution of its tractor industry thanks to technical and scientific assistance from Germany.

After wide-ranging discussion, the participants **confirmed** the importance of joint-ventures between industrialised and emerging countries as the keystone for a rational development of mechanisation in the emerging nations. They **underlined** the pressing need to define, prior to the stipulation of such joint ventures, the real requirements of the individual countries-- also with regard to the development of implements. In this connection, it is especially important to address the general context in which manufacturing takes place, with particular attention to the creation or development of supporting activities such as applied research and technical training at various levels, as well as the establishment of an adequate after sales service network.

They therefore **acknowledged** that the existence of efficient facilities for applied research and technical training of personnel plays an essential role in supporting the rational development of industrialised activities. Finally, they **recommended** that the governments of the receiving countries should enact laws which promote and encourage such joint activities, while at the same time maintaining rigorous control over them in order to assure the effectiveness and productivity of joint ventures in the agricultural sector.

CONCLUSIONI
E RACCOMANDAZIONI

Sessantacinque **esperti** provenienti da 29 **Paesi** e i rappresentanti di **FAO**, **AIT** e **UNIDO** hanno partecipato al 10° Meeting del Club of Bologna, organizzato sotto gli auspici della **CIGR**, per esaminare e discutere i seguenti argomenti:

1) Sviluppo delle tecnologie per la distribuzione degli inputs: reflui animali, letame, fertilizzanti minerali e irrigazione

2) Trasferimento di tecnologie fra pesi industrializzati e paesi emergenti: esperienze e risultati in alcuni paesi Asiatici e dell'Estremo oriente

Una breve sessione dei lavori, infine, è stata dedicata alla discussione sulla 2ª edizione aggiornata del Rapporto sullo sviluppo della meccanizzazione in 28 paesi.

I partecipanti hanno unanimemente raggiunto le seguenti:

Conclusioni e Raccomandazioni

1. Sviluppo delle tecnologie per la distribuzione degli inputs: reflui animali, letame, fertilizzanti minerali e irrigazione

Questo importante argomento, avente riflessi di carattere ambientale e interessante anche l'agricoltura di precisione, è stato discusso sulla base delle relazioni introduttive di: F. **Sangiorgi** (Italia), L. **Rodhe** (Svezia), P. **Balsari** (Italia) e E. **Kenig** (Israele). Un contributo scritto, inoltre, è stato presentato da A. M. **El Hossary** (Egitto).

I primi tre relatori - autori, rispettivamente, dei key-note reports sulla distribuzione dei reflui zootecnici liquidi e solidi e dei fertilizzanti minerali - ricordando la legislazione esistente nei vari paesi, hanno rilevato esservi un certo ritardo nella realizzazione di moderne tecnologie di distribuzione atte a rispondere alle esigenze di: valorizzazione agronomica dei vari inputs; qualità di distribuzione; risparmio di principi attivi; salvaguardia dell'ambiente (aria e acqua, in particolare). Questo il motivo per il quale sono state proposte, nelle relazioni stesse, nuove soluzioni atte a migliorare drasticamente le prestazioni distributive proprie delle tecnologie correnti. In particolare: F. **Sangiorgi,** illustrando le tecnologie costruttive attuali dei carribotte in Italia - più arretrate rispetto a Olanda, Germania, Francia, USA e Svezia - ha sottolineato l'esigenza di apportare innovazioni mirate a: migliorare la capacità di lavoro, ridurre il compattamento del terreno, garantire buona uniformità di distribuzione con bassi costi di gestione e contenere l'inquinamento ambientale specie a mezzo di idonei sistemi di interramento dei reflui. Ad esse va, tuttavia, aggiunta l'esigenza di adeguare i settori del trasporto e di dotare i carribotte con sistemi elettronici di controllo attivo e sensori appropriati da installare sia a bordo delle macchine, sia nel centro aziendale. L. **Rodhe**, dal canto suo, ha rilevato anzitutto l'esigenza di definire a livello internazionale alcuni parametri atti a: controllare la composizione del letame: quantificare la presenza di nutrienti; valutare l'efficienza nel lungo termine del ciclo di nutrienti nel terreno. Inoltre, ha sottolineato - pur ricordando i recenti progressi effettuati su prototipi di carri spandiletame in alcuni paesi europei (Svezia, Francia e Germania, in particolare) - la esigenza di promuovere un'ampia attività di ricerca coordinata al fine di pervenire alla realizzazione di mezzi di alta precisione distributiva, di migliore utilizzazione dei nutrienti e di minor danneggiamento del terreno provvedendo al contempo al miglioramento della salvaguardia ambientale. P. **Balsari**, poi, richiamate le elevate perdite di azoto distribuito con gli esistenti mezzi spandiconcime e non utilizzato dalle colture, ha svolto un'ampia panoramica sulle tecnologie esistenti, richiamando l'esigenza che: nel breve termine, si assista ad un ulteriore sviluppo dell'elettronica applicata alle macchine e di sistemi di geo-posizionamento delle stesse in tempo reale; nel lungo termine, si possa pervenire a soluzioni atte ad assicurare un lento assorbimento dei principi attivi, nonché a macchine che rispondano in termini qualitativi alle restrizioni ambientali che nei vari paesi vengono progressivamente adottate. Infine, E. **Kenig** ha illustrato dettagliatamente i più recenti sviluppi innovativi nel settore dell'irrigazione pressurizzata con riferimento ai tre metodi: a goccia, a micro-pioggia e a pioggia. Tali sviluppi consentono notevoli passi avanti nella regolarità di distribuzione e nella riduzione dei consumi d'acqua, con vantaggi economici e ambientali puntualmente richiamati. Le soluzioni indicate, tuttavia, non sono ancora sufficientemente diffuse e conosciute a livello degli agricoltori e meritano, pertanto, uno sforzo per favorirne l'utilizzazione in paesi sia industrializzati, sia emergenti. Da ultimo A.M. **El Hossary** ha richiamato i moderni sistemi in uso in Egitto, sistemi in progressiva diffusione in quel paese.

Dopo un'ampia e approfondita discussione, i partecipanti: **riconoscono** l'esigenza di un forte e rapido miglioramento qualitativo delle tecnologie esistenti al fine di dare risposta positiva ai problemi chiaramente esposti dai relatori e interessanti i paesi sia industrializzati, sia emergenti; **raccomandano** che venga compiuto ogni sforzo per definire rapidamente - sulla base di elevati standards comuni - le tecnologie e i processi più appropriati atti ad ottimizzare la valorizzazione agronomica dei vari inputs riducendo gli sprechi e i costi di gestione, migliorando la qualità della distribuzione e, conseguentemente, contribuendo alla salvaguardia dell'ambiente. **Sottolineano**, inoltre, l'esigenza di: incoraggiare a livello politico la definizione e l'uso delle nuove tecnologie supportate da opportuni dispositivi elettronici e gestiti in termini territoriali; promuovere coordinati progetti di ricerca internazionale e ampie campagne dimostrative dei vantaggi derivanti dalle nuove tecnologie in comparazione con quelle esistenti sostenendo i costruttori in questa loro attività; sviluppare la formazione degli agricoltori e la certificazione dei nuovi modelli; favorire il trasferimento di tecnologie appropriate e rispondenti nei paesi emergenti sì da consentire loro un aumento delle produzioni senza aggravi di costi né impatti negativi sull'ambiente. Infine, **confermano** l'esigenza di adottare per la soluzione del problema approcci multidisciplinari di sistema - includendo i pre-trattamenti - di cui la macchina distributrice è solo una componente destinata al razionale uso agronomico dei reflui zootecnici e dei fertilizzanti minerali.

2. Trasferimento di tecnologie da paesi industrializzati a paesi emergenti: esperienze e risultati in Asia e Estremo Oriente

Questo importante argomento è stato discusso sulla base dei rapporti introduttivi, ricchi di informazioni, presentati da K.U. **Kim** e G.J. **Chung** (Corea del Sud), **Wang** M., **Zhang** L. e **Geng** C. (Cina), A. **Firodia**, K.Th. **Renius** and R. **Bacher** (India).

Il rapporto di K.U. **Kim** e G.J. **Chung**, richiamando la forte evoluzione verificatasi nella Corea del Sud dal 1962 al 1997 quando sono state prodotte nel paese 279,000 macchine agricole motrici e operatrici, dà un approfondito resoconto dei risultati dalla cooperazione tecnica iniziatasi nel 1962 con la società giapponese Kubota e successivamente estesa a varie industrie di Giappone, Italia, USA e Germania.

Sulla base dell'esperienza acquisita i relatori affermano che il trasferimento tecnologico deve essere considerato come una transazione commerciale che soddisfa i mutui interessi delle due parti. Ricordano, quindi, come un efficiente metodo di trasferimento consista nell'assicurare un progressivo sviluppo della produzione (con aumento graduale del valore aggiunto) e delle capacità ingegneristiche delle industrie locali, sviluppo affiancato da idonee strutture per la progettazione, la sperimentazione e la valutazione delle varie macchine prodotte. In ogni caso, un semplice accordo di cooperazione tecnica risulta insufficiente ad acquisire tutte le tecnologie necessarie alla produzione. Si pone, infatti, il problema della capacità di completa utilizzazione delle tecnologie importate da parte dei produttori locali. Fra le diverse forme di trasferimento possibili, i relatori suggeriscono, come migliore, quella basata su vere e proprie joint-ventures di durata quinquennale, rinnovabile, nelle quali si facciano investimenti comparabili da entrambe le parti in causa e si provveda, poi, alla ripartizione equa degli utili dell'attività.

Wang M., **Zhang** L. e **Geng** C. tracciano, per la Rep. Popolare Cinese, un efficace escursus storico dell'evoluzione verificatasi dal 1959 al 1980, periodo durante il quale si è assistito ad un progressivo e via via accelerato sviluppo della meccanizzazione agricola. E', poi, dal 1981 che si è sviluppata soprattutto l'attività di creazione di joint-ventures con paesi industrializzati. In merito a questa attività, gli autori enumerano i maggiori problemi incontrati relativi all'esigenza di: aggiustamento della struttura produttiva interna al fine di offrire capacità sufficienti alla produzione di trattori di elevate potenze; accorpamento delle unità produttive locali; sviluppo delle attività di ricerca e sviluppo a supporto della produzione; aggiornamento della legislazione esistente al fine di facilitare la realizzazione di nuove attività in joint-ventures.

Ricordano come, allo stato attuale, siano già in atto forme di cooperazione con le principali industrie internazionali (J. Deere, N. Holland, Case, Yanmar, Kubota ecc.) oltre che con industrie sviluppatesi nella Corea del Sud, ribadiscono l'importanza prioritaria di ogni forma di trasferimento tecnologico da promuovere con leggi opportune che, difendendo le esigenze locali, siano tali da facilitare l'introduzione di imprese straniere, mediante: contratti prevedenti un progressivamente e crescente valore aggiunto locale; sviluppo di centri di ricerca applicata a servizio di queste nuove strutture, compresa la formazione di personale specializzato.

A. **Firodia** et Al., hanno presentato, infine, il caso specifico dell'evoluzione positiva verificatasi in un'industria di trattori in India, con l'assistenza tecnico-scientifica della Germania.

Dopo ampia e approfondita discussione i partecipanti: **confermano** l'importanza della creazione di joint-ventures fra paesi industrializzati e paesi emergenti quali chiavi di volta per consentire un razionale sviluppo della meccanizzazione in questi ultimi; **sottolineano** l'esigenza prioritaria di definire preliminarmente alla stipula di joint ventures, le reali esigenze dei singoli paesi relativamente anche allo sviluppo di macchine operatrici. In ciò assume particolare importanza la presa in considerazione della condizioni esterne alla messa in produzione con particolare riguardo alla realizzazione, o al rafforzamento, di attività di supporto concernenti la ricerca applicata e la formazione tecnica a vari livelli, oltre che di appropriate reti di servizio post vendita, **Riconoscono**, pertanto, il ruolo fondamentale di supporto al razionale sviluppo di attività industrializzate, giocato dall'esistenza nei singoli paesi di efficienti strutture di ricerca applicata e di formazione tecnica del personale. **Raccomandano**, infine, che i Governi dei paesi recipienti provvedano alla emissione di leggi incentivanti il verificarsi di queste attività comuni, mantenendo, comunque, un rigoroso controllo esterno delle attività svolte allo scopo di rendere efficace e produttiva la creazione di joint-ventures nel comparto meccanico-agricolo.

OPENING SESSION

WELCOME ADDRESSES

Apronimo Tassinari
President of UNACOMA

It is with great warmth and gratitude that I greet on the behalf of the National Union of Agricultural Machinery Manufacturers President Giuseppe Pellizzi and all the members (researchers, experts and representatives of industry and international organisations) preparing to open the 10th meeting of the Club of Bologna. I am happy to welcome them within the framework of EIMA's 30 years and I am grateful for the work they have carried out thus far in preparing for these meetings, creating assemblies capable of providing contributions which are always highly qualified and to the point. Over the years the Club has carried out analyses of agricultural problems, pondered over various factors which converge in the agricultural mechanisation sector and acknowledged special conditions in the various economic and geographic areas, thus achieving invaluable results. The ten years of the Club also marks an important achievement for UNACOMA too, having always promoted and supported the Association with conviction, and provides an occasion for reviewing the work carried out and appreciating the wealth of the issues, their relevance to the present day and their international importance. The Club of Bologna was founded in 1989 as a free association of experts and is now made up of authoritative representatives from 38 countries, as well as from such international organisations as the FAO and the agricultural organisation UNIDO, the Asian development Bank, the CIGR and others. The Club has contributed to the cause of mechanisation in terms of content and method. An examination of the acts, which have been published and systematically divulged over the years by UNACOMA, shows that issues taken up by the Club include mechanisation for strategic crops, innovative processes and products in the mechanisation industry, mechanisation for small farms, mechanical technologies for developing countries, aspects of energy, third-party operators and the control of pollution factors, as well as assessments of the influence of agricultural and trade policy orientations. On a methodological level this forum has been able to approach issues of general interest and those which are specifically technical in nature. Its authoritatives "Conclusions and Recommendations" give voice to the philosophy which motivates the formation of the Club, that of going beyond individual series of skills (engineering, industrial, economic, agricultural), to attempt a synthesis of the various approaches and translating the results of shared tasks into recommendations and orientations - which are political in nature - aimed at promoting technologies and methods, which take on strategic importance and show some prospects for application in the various countries. In spite of this, there is still a lot of work to be done, considering the developments in the economic sector and the expectations that this forum of experts raises in all public and private sectors operating in the fields of agriculture, environment and mechanisation. In an integrated and multidisciplinary perspective mechanisation must be capable of meeting such challenges as food security, the globalisation of the economy and markets, the trend of agricultural products and improving production in quality and nutrition, as well as those of natural adversities, safeguarding the environment and developing a wide range of activities, which will be characteristic of the rural economy in the coming years. The mechanisation industry can respond to the needs of modern agriculture and to orient investments in the right way, only through a well-informed, far-sighted approach, one which is not only responsive to the dynamics of the market, but able to interpret various social and economic development models and medium- and long-term prospects. I am gratified to remember that the first title discussed by this meeting during the inaugural session of 8th November 1989 was "Agriculture and Mechanisation after the Year 2000", an issue *that raised the general interest and curiosity of many operators, which the Club tackled through a study which turned out to be of great value. The experience of this decade - marked by a great lack of equality between the economies of different areas of the planet - has taught us that economic progress is not made in automatic and spontaneous ways, but requires the right orientation, multidisciplinary support and cooperation at international level. Working towards development, and consequently towards economic and social stability, is a political aim, but primarily an ethical one. For this reason as well I am grateful to the Club of Bologna and I renew my best wishes for profitable efforts through this gift of a print of old Bologna to the members of the Club. I thus extend the sentiment of closeness and regard felt by UNACOMA and the city of Bologna hosting us.*

Thank you very much.

Giuseppe Pellizzi

President of the Club of Bologna

Mr. President of UNACOMA, the applause you have herd is the expression of the feelings of gratitude of all the members of the Club to you and UNACOMA. Let me, in addition, express you my personal deep thanks for believing from the beginning to the role of the Club, its analyses and discussions had during the first 10 years of its life. This in order to try to promote the appropriate and rational development of agricultural mechanization in various parts of the world.

Let me now address few words to my Colleagues. First of all, I'd like to express them my warmest thanks for their consistently open and fruitful collaboration. There is no doubt that, during the ten years which have elapsed since its establishment, the Club has become stronger - in terms of its public image, the validity of the subjects covered and the conclusions reached. This is a particularly positive result which must be credited first and foremost to UNACOMA, who has supported, hosted and motivated us in our work for all these years. Our public image has gained prestige to the point that other countries have offered to UNACOMA - at any time it wish to withdraw from hosting our meetings - to immediately take over the responsibility of organising the Club. This is naturally a highly gratifying fact which does credit to all of us. But I hope that UNACOMA will continue to host us. In terms of membership, due also to the high patronage of CIGR, the Club has seen an increase in the number of participating countries, as well as securing the active participation of leading international organisations such as FAO, AIT, ADB, RNAM, UNIDO etc. But two problems remain to be solved: attracting a broader and more numerous representation of experts from the developing countries - particularly Africa and Latin America - and securing the participation of more representatives from industry. At present, and with a few praise-worthy exceptions, the world of industry has apparently shown only a marginal interest in our work. I therefore think we need to take further steps toward overcoming this twofold impasse, on the one part with the help of the various international organisations active in our group, and on the other with the associations of agricultural machinery manufacturers, whose representatives we have always invited to participate in our meetings. As regards the topics addressed at our meetings, I feel able to confirm their general validity, in consideration of many highly topical subjects of global relevance which were rationally presented and authoritatively discussed. In fact, as the President of UNACOMA underlined, our discussions often anticipated problems which later came to the forefront of global agriculture. I don't want to recall the various issues. But let me add the comprehensive report (which we hope to be able to update) on the conditions of mechanisation and the agricultural machinery industry in 30 countries all over the world. This is a unique document *which should constitute - if we will be able to complete it - a sort of "bible" for all the operators of the sector. However, the activity carried out is not, enough; in my opinion the "political" effects of our conclusions and recommendations during these first ten years have not been fully satisfactory. Likewise, there has been only a modest flow of technical information towards manufacturing and agricultural associations. This can partly be attributed to an inadequacy in our methods for diffusing information, but there is also - with certain praise-worthy exceptions - a certain failure on the part of us members of the Club to speed out within our countries the conclusions drafted at the end of each meeting. I therefore ask you for a more active collaboration in this respect.Consequently - while thanking UNACOMA for having set up an internet site (*) for the Club I strongly urge you all to help broaden the diffusion of our conclusions through specialist publications, scientific and trade journals, and the agricultural and industrial associations. All this is part of our "duty" as members of the Club. In this connection I also ask you all to provide the Club's Technical Secretariat with the names and addresses of your country's decision makers, at the national and regional levels, for agricultural and mechanisation policy, so that we can periodically send them information about the Club's activities. I thank you all for your open collaboration and, once again, I extend our thanks to UNACOMA and I wish to all of you a pleasant and fruitful meeting in Bologna.*

(*)
http://www.smart.it/unacoma/pubblico/attivi_gb.html

SESSION 1

Advancements on the technologies for inputs distribution

Chairman: Jaime Ortiz-Cañavate, SPAIN

Advancements on the technologies for inputs distribution: the case of animal waste slurries

by ***Franco Sangiorgi***

Italy

1. The starting point

The Club of Bologna has already had the opportunity, in the past, to discuss the fundamental issues covered in this paper, albeit in different years and in different contexts. In particular, I would like to cite the paper presented by A. Jongebreur in 1990 [1], which is a point of reference for all matters pertaining to the distribution of animal waste, and the paper by H. Auernhammer (1997) [2] concerning the applications of electronics in agricultural machines.

Neither must we neglect, within this context, the option presented by R. Hegg in 1991 as part of the LISA project [3], and its implications for strategic soil fertilization decisions.

However, any discussion of this particular topic must necessarily be highly country-specific. In fact, the present-day slurry tanker is simply the result of an interaction between several external factors such as the agronomic, climatic and economic context, as well as the legislation in force.

1.1. Animal housing

Up until the first half of this century, the term "slurry" was virtually unknown in the agricultural world. The only familiar term was "manure", meaning a combination of solid and liquid animal waste mixed with straw [4]. In fact, traditional agricultural methods refer exclusively to manure, whereas slurry is produced in free livestock housing systems with low use of manpower. Therefore, in view of the fact that modern animal housing is based on minimising labour requirements and excluding the use of straw, slurry is the subproduct to which we must devote our greatest attention. There are different types of slurry, but the most significant characteristic is undoubtedly the degree of dilution of the dry matter, which influences both its potential for subsequent agronomic use and the associated operating costs. Slurry dilution ratios can vary by a factor of 10 and more [5], [6].

1.2. Environmental problems

It is precisely as a result of dilution and the associated high running costs, as well as certain rather questionable ideas (for example the concept that "dilution is the solution to the problems of pollution") [7], that for a long time the preferred method was to directly discharge slurry - especially if diluted - into surface waterways. This gave rise to considerable problems with pollution (essentially eutrophication). In fact, according to studies conducted in Italy as early as the '70s, agricultural activity and stock farms were responsible for 60% of the eutrophication in the Adriatic sea. What's more, a similar situation was also observed in Northern European countries characterised by intensive livestock farming [8].

The environmental problems caused by intensive agriculture (livestock-keeping, arable farming, horticulture) are directly related to a surplus of minerals. The most important such phenomena are:

- phosphorus-saturated soils;
- leakage of nitrates into ground water;
- eutrophication of bodies of water.

Another important phenomenon that created environmental problems is the emission of ammonia from animal manure, which causes acidification [1].

Numerous laws have been issued at the European, national and regional level to minimize the negative effects of improper use of agricultural waste.

These laws regulate both point and non point pollution sources.

However, although the former is fairly easily controlled, by requiring stock farmers without agricultural land to construct treatment plants, non point pollution is much more difficult to reduce. Attempts have been made to control non point pollution by setting limits on the stock load per hectare, based on the quantity of macronutrients in the animal waste, for example the 170 kg/ha limit for N specified in Europe on a farm basis by the Directive on Nitrates (91/676/EEC).

In practice, this presupposes:

- knowing the N content of the effluent (although a data base annexed to the legislative packet is normally used as a reference);
- availability, even though not explicitly required by the current legislation, of equipment capable of evenly distributing the permitted amount of effluent;
- in the case of approved spreading plans, increasing the quantity of N contained in the effluent. The spreading plan thus takes on considerable importance in the choice of equipment for slurry distribution.

What's more, it is also important to consider pollution and the associated legislation on the emissions of gases responsible for: the *greenhouse effect* (CO_2), as condition for the destruction of the stratospheric ozone layer (CH_4), and the formation of *acid rain* (NH_3). Here again, these result from the decomposition of organic matter contained in the waste, which varies in magnitude from country to country. In any case, there is clearly a need to safeguard organic N as much as possible, and to utilise biogas (mixture of CH_4 and CO_2) more systematically for energy purposes.

1.3. The agronomic constraints

The introduction of limits on the quantity of effluent that can be distributed, linked to the existing live weight or to the quantity of nitrogen or phosphorus produced, means that the slurry must be spread in such a way as to maximise its agronomic effect. In practice, it is necessary to ensure that the nutritive substances contained in the effluent can be assimilated by the crops and fixed - chemically and/or biologically - into the soil.

This means that the slurry needs to undergo suitable treatment prior to spreading (a well-designed storage period lasting 120-180 days, as required by most countries, appears suitable for this purpose), and that spreading must be performed during specific periods and using methods geared to minimising emissions into the atmosphere, leaching and runoff.

To achieve these objectives, it is necessary to use appropriate equipment, capable of metering the effluent and incorporating it into the soil, as well as software packages for the management of farm waste.

What's more, we must not forget that the macronutrients content of the effluents is skewed in favour of P and K. Therefore, if the fertilization is based on P, it will be necessary to supplement the mineral N, whereas if the fertilization is based on N there will be an excess of P with consequent risks to the chemical equilibrium of the soil. We need only mention, in this regard, the 300,000 phosphorus-saturated hectares in Holland [1] which prompted a radical alteration of the system for the territorial management of livestock slurries [9]. What's more, there remains the problem of increasing crop yields, which requires increasing the quantities of distributed slurry. However, if we accept the concept of assessing fertilization efficiency through the percentage utilisation of nutrients, then for a given level of efficiency, the more we fertilize, the more nutrients will be found in the water. Therefore, if we wish to reduce the loss of nutrients in general terms (an action that is in any case beneficial from the environmental and energy standpoints) (especially of N) we need to operate with equipment that can effectively control the spreading operation, while at the same time using appropriate software packages with on-line links to weather forecasting services to reduce the risk of pollution. This brings us fully within the province of precision farming [10].

1.4. Farm management

All the above, however, is at odds with the interests of farm management. In fact, the handling of livestock slurries constitutes a problem, a cost and a nuisance.

A problem: because, for optimal agronomic results, the slurry must be treated and stored with great care, and spreading the slurry within the optimal time-frame requires equipment capable of high work rates [11]. In particular, in the case of slurry tankers, there are problems associated with their weight and foot-print on the ground, which increase in proportion to their capacity, and this also hampers access to the fields in the presence of standing crops [12].

A cost: due to the considerable manpower requirements (in the case of slurry tankers of modest capacity) or substantial capital investments (in the case of high capacity slurry tankers, or fixed fertilization-irrigation systems). Slurry distribution compares so unfavourably with the ease and effectiveness of chemical fertilization, that any attempt to convert stock farmers without the imposition of sanctions must be doomed to failure.

A nuisance: because slurry always consists of malodorous animal waste with antisocial characteristics, and also because, without suitable (extremely expensive) analyses or special instruments (still in the development stage) [13] it is difficult to have an idea of the quality of the product that is being spread in the field.

2. The technology of slurry tankers

Slurry tankers are special trailed machines, generally consisting of: a frame with 1, 2 or 3 axles; an ambient pressure or vacuum slurry tank; a positive pump or vacuum pump connected to the PTO; a slurry distribution system; hoses; optional safety valve; optional pressure gauge [11] (**Fig. 1**). This same basic block diagram recurs in slurry tankers from many different countries. However, the today's slurry tankers are not general-purpose machines, because their construction must take local constraints into account. Therefore, their production and marketing tends to be somewhat localised. There are only a few basic components which have an international market, such as positive pumps, active filters, active distributors. The differences between the liquid tankers manufactured in different countries concern:

- the number of axles, or the permitted load per axle;
- the slurry carrying capacity;
- the type of pump and hence the type of tank;
- the slurry distribution system.

For illustrative purposes, the Italian situation is described below, along with data from a few other countries.

2.1. Production of slurry tankers in Italy

In order to investigate the production and technology of slurry tankers in Italy, a study on the national market for these machines was undertaken. It involved a general survey of the manufacturers and of the slurry tanker models constructed [14].

In Italy there are 28 national manufacturers, which produce a total of 190 slurry tanker models.

No foreign companies have attended the most recent specialist trade fairs, nor have they advertised their products in the trade magazines. This is indicative of a highly localised and provincial market.

Upon examining the manufactured models, we note a prevalence of machines with vacuum tanks (87%), while pump tankers account for just 13%.

The average number of structurally distinct models offered by each company ranges from 2 to 17, but 50% of companies offer less than 5 different models (**Fig. 2**).

The slurry tankers are for the most part trailed (175 models; 92.1%), while a small part are mounted on trucks or articulated lorries (11 models; 5.8%). There are no self-propelled models.

The minimum power requirements for trailed machines, broken down according to spreader category and number of axles (**Table 1**), increase when moving from single axle to multiple axle models, but without any relation to the type of pump. Generally, the models conform to the maximum permitted statutory load (Art. 207, New Italian Highway Code, 1992).

From **Table 2** we note that certain models are well above the legal weight limit, and therefore cannot circulate on the road when fully loaded.

Figure 3 illustrates the relation between the average fully-loaded weights and the power requirements of the slurry tankers: note that the larger models require high-power tractors which must therefore have appropriate adhesive weights.

Furthermore the tank itself must have a certificate of conformity attesting its resistance to positive or suction pressure.

As a function of the requisite level of vehicle type approval, slurry tankers can be divided into three categories: total type-approval, partial type-approval, not subject to type approval.

Total type approval is issued when the vehicle is defined as whole and indivisible unit (this is the case of the non-replaceable tank which is a weight-bearing component). Partial type approval is required when the slurry tanker consists of a chassis on which a separate tank is mounted. In this case, manufacturers obtain type-approval for a single chassis on which they can then mount all sorts of different tanks and accessories.

If we separate out the models not subject to type approval (weight < 1500 kg), we find that 61.7% of slurry tankers have partial type approval, 14.4% have total type approval, and 8.5% do not have type-approval for circulation on the roads.

The average carrying capacity is 7.1 m^3, a relatively modest value in view of the present-day requirements of farms.

From **Table 3** we see that the highest capacity tanks are mounted on pump tankers because, for any given overall size, they can provide a greater effective capacity (the classic cylindrical shape can be abandoned).

Mixing systems are not generally considered very important during the machine design and construction phases (**Fig. 4**). The majority of models (146) do not have any type of system for stirring the slurry during transport and distribution, while in the case of pump tankers there are 8 models which offer the possibility of recirculating the slurry using the pump. Active mixing systems, for both types of slurry tanker, are found on just 7 models.

Grinding-filtering systems are infrequently used and, in the few cases found, are always of the rotating blade type, imported by specialist foreign companies. The tyres are for the most part of conventional type, ranging from 10 to 15 inches in width.

The type and width of the tire carcass, coupled with the average weight of the fully loaded tanker, indicate that the choice of tires does not take into account the weight exerted on the wheels, and that neither is the ground pressure of the slurry tanker taken into consideration.

However there remains the problem, especially with pressurised cylindrical tanks, that the adoption of wide low-pressure tires would put the overall machine dimensions outside the maximum limit permitted by the "roads code".

The average per-unit costs of slurry tankers, referred to a single m^3 of capacity, are given in **Table 4**. We note first of all that the average price of a pump tanker is higher than that of an equivalent vacuum tanker; however, if we examine the costs per m^3, these differences decrease as we go from single-axle to three-axle models. The higher capacity pump tankers are therefore competitive with the vacuum models.

2.1.1. Spreading implements

Manufacturers offer the following types of distribution systems for the spreading opera tion: baffle plate (traditional and vertical, with fixed or variable angle); injectors (deep for arable soils, shallow for grasslands); sprinkler systems; and boom for surface spreading. The system most commonly adopted by manufacturers (**Fig. 5**) is the baffle plate which, by virtue of its ease of use and high work rate, simplifies the distribution of livestock slurries in the field. We note, moreover, that the sprinkler distribution system, which was commonly used up until a few years ago, has now been superseded by injectors, whereas surface spreading booms occupy a marginal position on the market.

The injectors which have been developed, and are still marketed in Italy today, are similar to subsoilers. In addition, simple solutions have been developed, realised directly on the farm or by generic blacksmiths, such as attaching spike tooth harrows to the slurry tanker in order to immediately incorporate the slurry distributed through hoses connected directly to the tank.

Systems for adjusting the application rate per unit surface are viewed by manufacturers as non-essential components in the design of a distribution system (**Fig. 6**). Only 10% of the models have rotary flow dividers effectively designed to produce a virtually uniform application rate. On the other hand, there are no models which incorporate metering systems for controlling the quantity distributed per hectare.

2.1.2. The regulatory problem

If Italian companies are to undertake innovatory efforts and begin investing in applied research, they need to be supported by a less restrictive legislation that allows them to construct new models. This would enable them to operate (and compete) on equal terms with their counterparts across the Alps. It is also necessary, given the absence of harmonised regulations at the European level, for laws to be enacted that eliminate barriers to the free circulation of goods. In particular, the aspects of the Italian legislation which penalise our manufacturers concern the limits placed on the maximum weight which can be transported per axle, and on the overall dimensions of the vehicle.

2.2. Examples from other countries

In the absence of other more wide-ranging studies on the market situation of these machines in other countries, we report below on the results obtained from processing data gathered at specialist trade fairs and from sources cited in the bibliography.

The Netherlands: at a national trade fair held in Lelystad in September 1998, data were collected concerning the technical characteristics of 29 slurry tankers exhibited at the fair. Some of the machines also originated from Germany, France and Belgium.

The Dutch market has the highest percentage of trailed models (77%), although there is also a considerable percentage of self-propelled models (23%). The average weight and capacity of the models exhibited at this trade fair (respectively 23.20 t and 13.4 m^3) are much higher than the corresponding values for Italian models, 10.45 t and 7.1 m^3. In consequence, the Dutch models generally use large cross section radial tyres with automatic adjustment of the tyre pressure (**Fig. 7**).

With regard to pumping systems, the situation in The Netherlands is the opposite of that which exists in Italy: 40% of models are vacuum tankers, and 60% are pump tankers.

For what concerns the distribution systems, we note the total absence of sprinkler or baffle plate solutions. A few systems use surface booms (10%), a larger number use arable soil injectors (31%) and the remainder use shallow grassland injectors (59%). The constructive and functional characteristics of the distribution systems are different from those used in Italy, with lower depths and less distance between the injectors and greater work widths (also due to the different types of soil).

Manufacturers here consider the application rate adjustment system to be an essential component in the design of a distribution system: in fact, all the models have a hydraulic rotating slurry dispenser for uniformly subdividing the flow of slurry to the injectors. The flow rate and the application rate per hectare are metered by controlling the ground speed of the machine; electronic systems for adjusting the application rate as a function of ground speed are becoming more common. Systems for mixing and grinding-filtering the slurry on the slurry tanker are considered essential components, and fitted as standard on all machines with a positive pump system.

Germany: in view of the limited number of models examined, an analysis of the tests conducted by DLG [15] enables us to draw only a few general conclusions concerning the constructive characteristics of the machines. In fact, distribution uniformity tests were carried out on 7 slurry tankers using 11 different distribution systems.

For what concerns the structural components, all the tankers were trailed models with either a positive pump or vacuum system. Some of the models incorporated systems for mixing the slurry, through recirculation in the case of pump tankers, or operated by an independent hydraulic motor in the case of certain vacuum models. The maximum application rate obtained during the tests was 64 m^3/ha at 2 km/hour, and the minimum application rate was 5 m^3/ha at 8 km/hour. Most of the distribution systems tested (n°7 out of 11) were of the baffle plate type (this system is therefore still widely used in Germany). The values of C.V. were between 9.5 and 16%, which is considered to be excellent for this type of distribution. In fact, the manufacturers devoted particular attention to the distribution implement, which was carefully shaped and contoured to obtain a C.V. below the 15% limit required for certification. On the other hand, we noted an absence of constructive refinements such as hydraulically operated suction arms or certain types of suspensions (none of the models examined incorporated the hydraulic arm, and only one model had leaf spring suspensions). The other distribution implements were surface booms and injectors for grasslands and arable soils. All the models had structural characteristics that were conceptually similar to those of the Dutch models, with high work widths, a high number of injectors and a limited depth of injection.

France: we examined a technical manual [16] which schematically sets out the structural characteristics of slurry tankers which most influence the quality of distribution, such as the pumping system and the hydraulic rotating slurry dispenser. It also reports the results of distribution uniformity tests conducted on slurry tankers equipped with baffle plate, surface boom and injector distribution systems. The average slurry application rate is reported to be approximately 30 m^3/ha.

USA: we examined regional technical manuals [17] and [18] which set out the maximum performance of the machines available on the market, as well as the most significant constructive characteristics from the point of view of optimal distribution.

Denmark and *Sweden*: the respective institutes of soil and plant science have presented some prototype machines with technical features aimed at improving the uniformity of distribution. Special attention has been given to the volatilisation of ammonia in the atmosphere, and hence to the systems for reducing this emission (e.g. by operating on various types of injectors).

This brief overview indicates that all the nations with industrialised agriculture have studied or are studying the problem of effluent distribution, especially with regard to the implements that actually perform the spreading operation. The non-industrialised countries, on the other hand, do not appear to be considering up to now this issue - although it would be interesting to hear from the discussion whether this is in fact the case.

3. Alternatives to the use of slurry tankers

For what concerns non-traditional slurry distribution systems, we can cite the fixed umbilical hose system and the self-propelled umbilical hose system, also known as the hose reel [19] (**Fig. 8**).

The former consists of a fixed irrigation system with underground tubing that is normally used for irrigation, but which also doubles as a slurry distribution system.

The second system, which is becoming more common, can also be used for irrigation, however in this particular context it is exclusively dedicated to the distribution of slurry. It consists of self-propelled hose reels which provide a link between the place of storage (fixed farm cistern, or mobile storage tanker at the side of the field) and the place of distribution. This category also includes umbilical systems with a flexible hose that winds onto wheeled units similar to the hose reels.

The most commonly used distribution system is the sprinkler, opportunely modified for the distribution of slurry (low pressure, near-horizontal angle of the jet, special spray baffle, etc.) but boom systems are being developed which provide good work widths (20 - 40 m) while at the same time avoiding excessive dispersion of ammonia in the atmosphere.

Some advantages of these systems over traditional slurry tankers are:

- excellent work rates, with reduced manpower requirements;
- minimal or zero soil compaction;
- "fertirrigation" or distribution of slurry on standing crops;
- depreciation of the equipment which can also double as an irrigation system;
- good uniformity of distribution;
- low running costs.
- The drawbacks are mainly connected with the environmental aspects and the potential for improper use:
- dispersion of ammonia and malodorous compounds into the atmosphere;
- danger of spreading in adverse weather conditions or during periods when spreading is forbidden;
- danger of distributing high quantities of slurry per unit surface;
- necessity of operating on plots which are of adequate size, and approximately rectangular in shape.

4. Adapting the technology to agronomic and regulatory requirements

We must first of all remember that any method for managing livestock waste must necessarily incorporate an animal housing systems that minimises dilution of the slurry. In fact, the present-day level of dilution renders the agronomic use of livestock slurries uneconomic, and this partly explains the environmental problems associated with their management. Therefore, the discussion below shall essentially refer to the effluent "as is".

The increased sensitivity of stock farmers and policy makers to the problems of pollution resulting from uncontrolled distribution of inputs - particularly chemical products - has led to an enhanced environmental awareness. As a result, new alternative farming practices are making headway, helped along by substantial public subsidies promoting their adoption (for example the CEE 2078 Mis A1 program). However, these new practices require the use of appropriate machines, as noted by Hegg in his above-mentioned paper, which reports that there are still some refinements that can be made in machinery designed for manure application to make the systems more efficient [3].

The existing technology is inadequate for meeting the agronomic requirements and complying with the legislation on environmental protection. In fact, at least with regard to the Italian situation, certain developments have even been detrimental: consider for example the result of increasing the carrying capacity while at the same time containing the overall dimensions and the load per axle; this has led to the adoption, on larger slurry tankers, of carriages with 3 steering axles which heavily damage the soil at the moment of turning.

The technological evolution of slurry tankers will see their enhancement with servo-mechanisms, electronics and information technology, as set out by Auernhammer in the introduction to his talk.

Through electronics, technology becomes intelligent and can communicate. Unlike the applications developed up to now, in which a human acts as a link between the farm management and the mobile units, it is now possible to integrate the technology directly into management [2].

Clearly, there is a need to invest in this sector to bring it up to date, by focusing on a variety of aspects as anticipated in the SWAMP Project financed by the E.U., and as is now being done in the Waste Project, financed by the Italian Ministry of Research through the National Research Council (CNR) [20; 21].

The principal aspects currently being addressed to improve the technology of slurry tankers are the following.

4.1. Improvement of the transport systems

Given the inescapable need to increase the volume capacity of slurry tankers, it is clearly necessary to modify the legislation (possibly at the European level) which sets a limit on both the overall dimensions and the maximum load per axle. The increased volumes and the resulting need to reduce the tare weight will promote the development of tanks constructed from alternative materials (for example, fibreglass) which are more lightweight and easily shaped than steel. At present this is held back by the legislation in force, which for reasons of safety only contemplates the type approval of steel tanks for circulation on the roads.

The adoption of very low pressure tyres should be made mandatory in order to limit the damage to the soil, and likewise for adjustable-track axles. In Italy, all this has not even been considered yet.

4.2. Improvement of the distribution systems

These systems must be able to achieve truly uniform distribution of the slurry, while also minimising the contact between the effluent and the air in order to reduce emissions of ammonia and odours in general. For this reason, the use of baffle plate systems - and even more so of sprinkler systems - should be prohibited. The implements for incorporating the slurry into the soil, which have so far been designed with the sole aim of injecting a maximum quantity of slurry per unit surface, should be developed and improved to the meet highly diverse agronomic needs arising from the variability of soils.

If we consider that a country with fairly homogeneous conditions such as The Netherlands has at least a dozen different coulter implements available on the market, while in Italy there no more than a couple of types, the importance of developing these components becomes clear.

In any case, regardless of the type of equipment that is chosen, it should guarantee uniform distribution of the slurry and make it possible to determine the optimal distance between adjacent passes. In fact, at the current state of the art the quality of distribution is modest, and this results in poor uniformity (on average C.V. > 50% according to tests conducted in 1998 and 1999) [22]. The CV cannot be improved without the use of lobe pumps or suitable flow dividers.

The above issues were addressed in general terms during the Rennes Workshop [23].

4.3. Introduction of new farm management systems

In the interests of environmental conservation, the management of livestock slurries should be based on "dynamic" fertilization plans which continually (and on an annual basis) readjust the slurry and fertilizer application rates as a function of the climate conditions and crop yield performance. These fertilization plans should be part of a more complex software program that is capable of being interfaced, perhaps by means of a smart-card, with the slurry tanker or distribution system [10].

4.4. Introduction of electronic controllers on-board the slurry tankers

Although these are not implements as such, it goes without saying that a data reception system must be equipped with an electronic sys tem for controlling the implements of the machine on which it is installed.

A machine controller capable of adjusting the slurry application rate on the basis of information received from a special software was presented last year at EIMA [24].

The principal component of this machine is the speed variator that is coupled to the distribution lobe pump. In this particular case, the quantity distributed is adjusted only as a function of ground speed (**Fig. 9**).

The next logical step is the incorporation of sensors which measure the characteristics of the distributed slurry in real time, a possibility that was mentioned at the ECCAEA [25] Workshop held in Lovanio. This would make it possible, by continually regulating the opening and closing of the distribution valves, to adjust the slurry application rate to match a target value determined by the software. This is a research topic that was discussed during the ECCAEA Workshop held in Braunschweig [26]. Experiments in this regard have been conducted as part of the SWAMP projects [20] and others are currently in progress as part of the CNR Effluent Project [21] (**Fig. 10**).

4.5. Introduction of supervision by outside authorities

Once the target application rate for nutrients and livestock slurries has been determined, it is possible to collect useful data for evaluating the polluting effects of livestock slurry distribution. However, from the point of view of control (also at the farm level) it would be useful to have additional information such as the geopositioning of spreading, the dates and quantities of distributed slurry, etc. This information can be logged by incorporating a GPS and appropriate motion sensors into the slurry tankers.

Also in this case, a system is being currently tested as part of the CNR Effluent Project [21].

5. Conclusions

The slurry tankers currently on the market represent a technology that has become obsolete, both in agronomic and environmental terms.

The technological upgrade, which can incur cost increases of up to 50%, is undoubtedly justified by the needs of a modern and ecologically sustainable agriculture.

All the necessary technology is already available, with the exception of the specialist software which is being developed in research projects such as the one financed in Italy by CNR, but needs to be opportunely assembled.

However, it is unlikely that this technology will be able to develop independently, without any regulatory measures for promoting its adoption.

What's more, because this is not a mature product, it will be necessary to first develop the technological package as a whole and then to test it under real conditions in order to permit an objective evaluation. In fact, in addition to the slurry tanker itself it will be necessary to: test and adapt the performance of accessory components, develop and adapt the sensor components and the entire information system, both on-board the machine and in the farm centre.

It goes without saying that the technological packet described above would open the way to globalisation of the slurry spreader market, with only a few country-specific adaptations being necessary, primarily at the software level.

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Fig. 1 - New slurry tanks have to be equipped with various electronic and mechanical devices in order to protect environment, to distribute appropriate rates of fertilizers and to follow the existing legislation

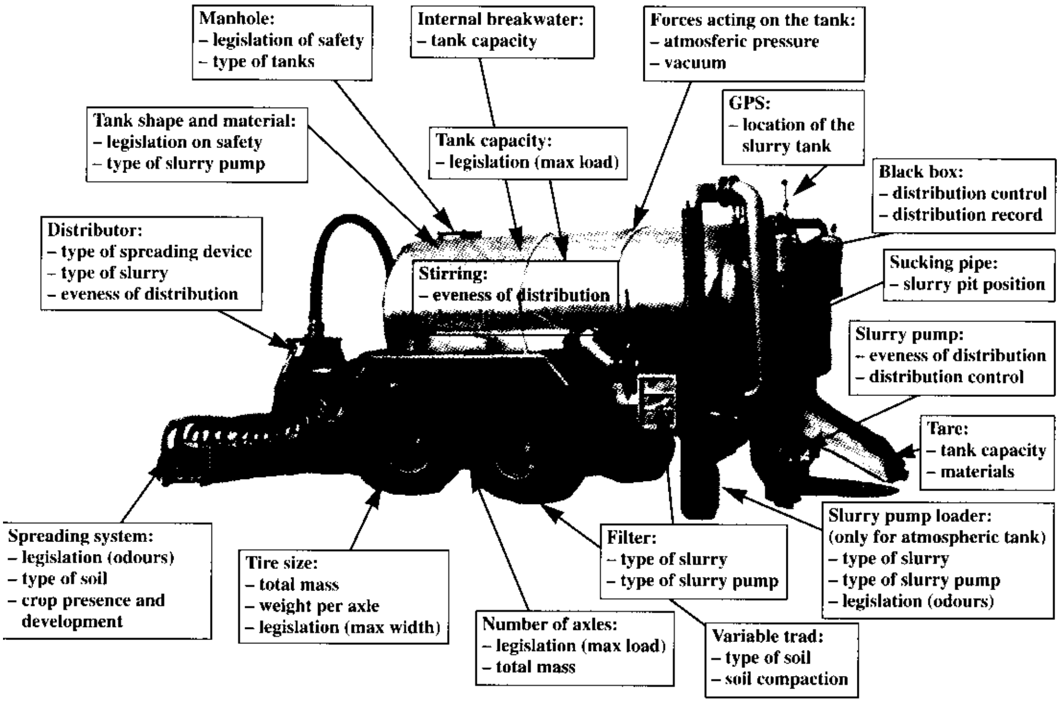

Fig. 2 - Average number of models per manufacturer in Italy

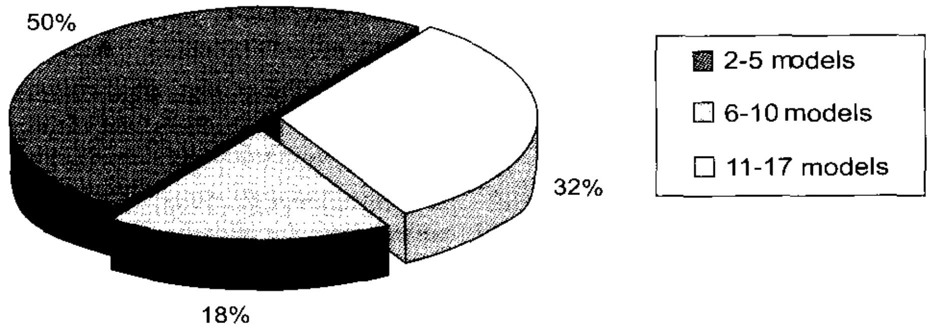

Fig. 3- Relationship between full masses and power required

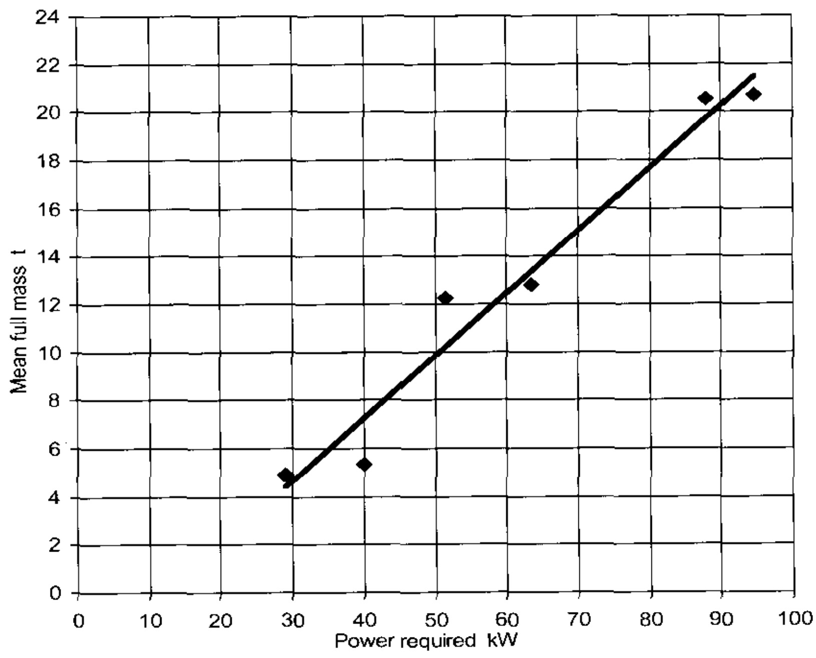

Fig. 4 - Type of stirring device proposed by manufacturers in Italy

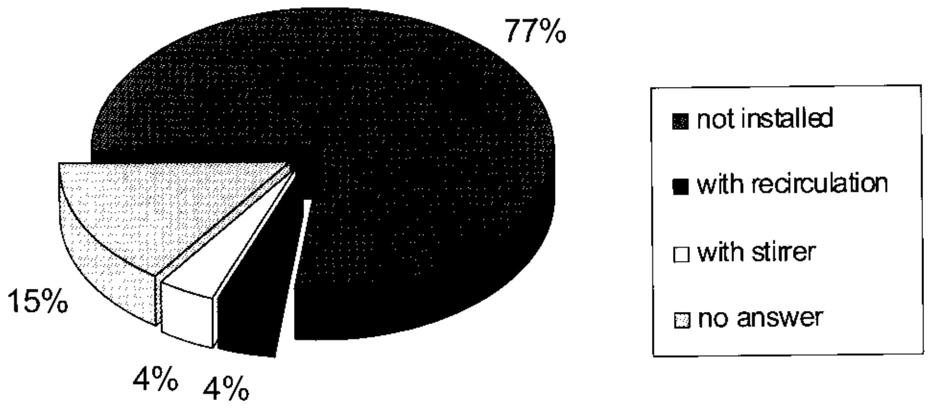

Fig. 5 - Spreading systems proposed by manufacturers

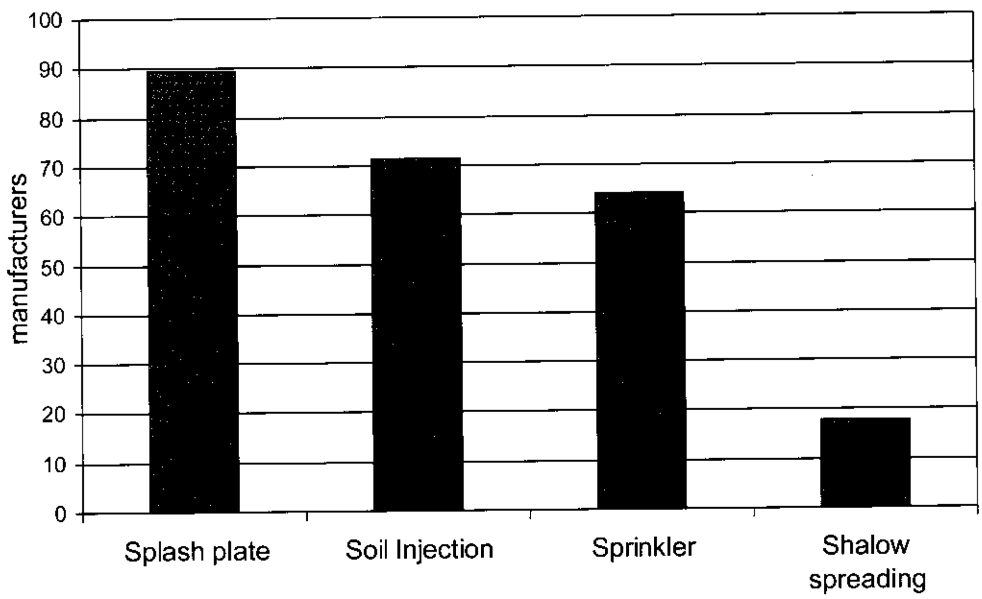

Fig. 6 - Devices for controlling the amount of slurry to be spread

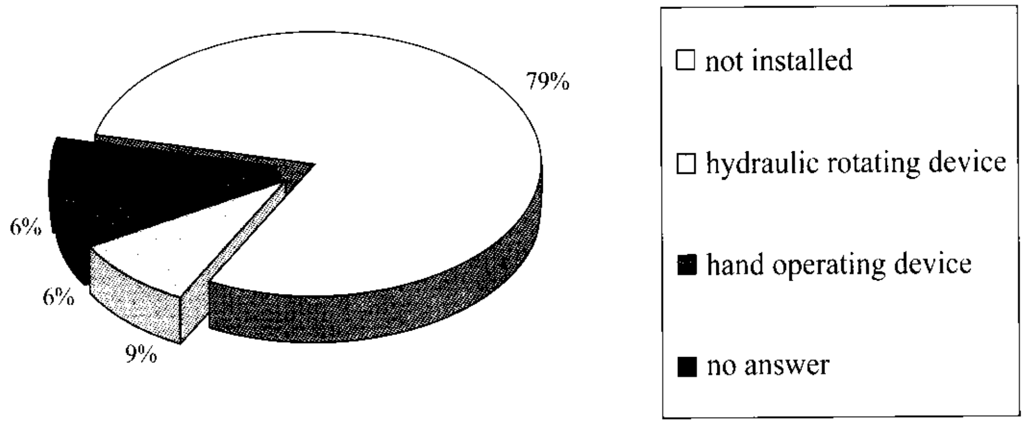

Fig. 7 -An Italian slurry tank with low pressure tyres in order to reduce soil compaction

Fig. 8 - Different alternatives for slurry transport: Mechanical - - -; Hydraulic ___ [19]

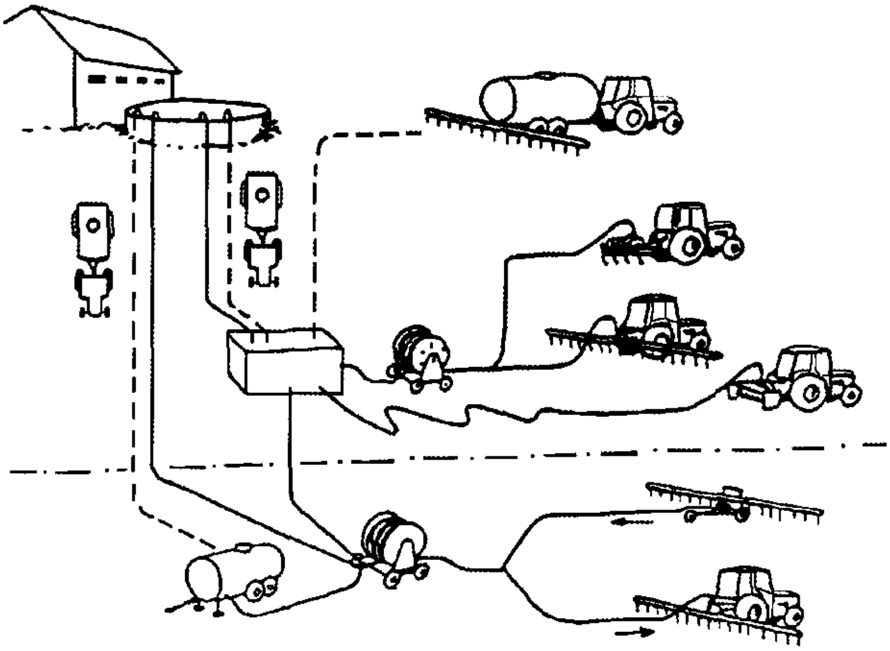

Fig. 9 - The functional scheme of the control system devised for a slurry tank

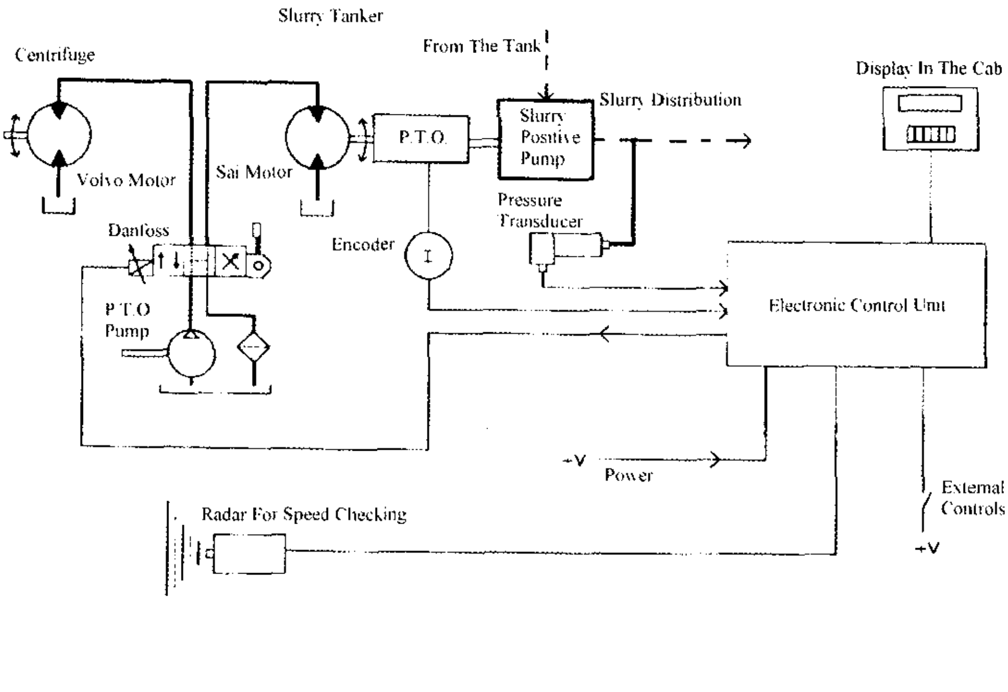

Fig. 10 - Sensor for in-line nutrient content of animal slurry installed in a slurry tank devised in the frame-work of the SWAMP Project

Table l - Minimum power requirements for different models of slurry tank

TYPE OF SLURRY TANK	POWER REQUIREMENT (kW)			
	average	minimum	maximum	$n°$
with compressor (1 axe)	29	9	55	98
with compressor (2 axes)	64	29	100	47
with compressor (3 axes)	95	80	130	21
with positive pump (1 axe)	40	26	59	17
with positive pump (2 axes)	52	30	80	6
with positive pump (3 axes)	not available			1
totals				190

Table 2 - Full mass of different types of slurry tanks

TYPE OF SLURRY TANK	TOTAL MASS (kg)					
	average	minimum	maximum	mass per axe	tare average	$n°$
with compressor (1 axe)	4876	1500	8300	4876	1319	98
with compressor (2 axes)	12811	8000	16500	6405	3928	47
with compressor (3 axes)	20680	14000	23260	6893	5412	21
with positive pump (1 axe)	5297	2860	7450	5297	1225	17
with positive pump (2 axes)	12233	13300	17900	6117	3466	6
with positive pump (3 axes)	20500	20500	20500	6833	3000	1
average between all the models	10445	—	—	5507	2918	
totals	—	—	—	—		190

Table 3 - Capacity of the different models of slurry tanks

TYPE OF SLURRY TANK	SHALLOW CAPACITY (m^3)			
	average	minimum	maximum	$n°$
with compressor (1 axe)	3.54	1.00	6.00	98
with compressor (2 axes)	8.82	5.00	12.00	47
with compressor (3 axes)	14.47	11.00	16.50	21
with positive pump (1 axe)	3.56	2.00	6.00	17
with positive pump (2 axes)	11.77	10.00	15.00	6
with positive pump (3 axes)	17.50	17.50	17.50	1
average between all the models	7.11	—	—	
totals	—	—	—	190

Table 4 - Average prices and specific prices for different type of slurry tank

TYPE OF SLURRY TANK	MODELS	AVERAGE PRICE (000 it£)			
	$n°$	average	min	max	it£/m^3
with compressor (1 axe)	98	13116	5600	25000	3707
with compressor (2 axes)	47	34806	18000	54700	3947
with compressor (3 axes)	21	55402	38000	62000	3830
with positive pump (1 axe)	17	17183	11670	26646	4829
with positive pump (2 axes)	6	45435	41870	49000	3862
with positive pump (3 axes)	1	67000	67000	67000	3829
average between all the models		25516			4001
totals	190				

**ADVANCEMENTS
ON THE TECHNOLOGIES
FOR INPUTS DISTRIBUTION:
THE CASE OF MANURE**

by ***Lena Rhode***
Sweden

1. Introduction

A survey of the solid animal manure handling in Europe [I] shows big differences between countries. Solid manure handling systems dominate in the Czech Republic, Finland and in parts of Belgium. In Bulgaria up to 80% of the manure is assumed to be handled as solid, including slurry transformed to solid manure in lagoons. Solid manure handling is not so dominating in, e.g., England and Wales (50%), Austria (40-50%), Sweden (approximately 40%), Switzerland (36%) and Italy (more than 50% of the cattle manure production). In some countries, only a small part of the manure is handled as solid manure as in Norway and Northern Ireland (10%) and the Netherlands (6%). The future development of solid manure handling appears to be rather uncertain in most countries. The structural change towards larger farms often means a decrease in handling the manure as solid. On the other hand, the importance of animal care and welfare may increase the number of housing systems with solid manure.
Other results from the survey show a big variation between countries of solid manure produced per animal and the content of plant nutrients in solid manure. Where possible, solid manure is mainly used on arable land. The use on grassland is common primarily in mountain regions. Few details are given in the survey about present solid-manure spreading equipment.

2. Physical and chemical properties of manure

Solid manure and residues of bedding are often heterogeneous products. Manure properties affect the performance and reliability of the spreaders and other manure handling equipment in practical use on farms. Manure properties also affect the strategy of spreading (rate, field).
Accordingly, it is important to know the properties of the manure before choosing equipment and strategy. Solid manures for testing have been divided into five classes, defined by means of relevant physical properties as the bulk density and the dry matter content (**Fig. 1**) [2]. In a proposal for CEN standard manure classes 1-4 (bovine and pig manure) are proposed to be used when testing solid-manure spreaders [3].
The reliability of analysed properties of manure is very much depending on the sampling technique. When taking samples for analyses of chemical properties, small samples are required. JT1 has developed a sampler for taking samples from solid manure heaps 141. In a field study, when taking five samples from a heap with a height of 0.8 m, the expected 95% confidence interval was about ± 20% of the average dry matter content. With 10 samples, the expected 95% confidence interval was about ± 10% of the average. The average chemical content of the samples agreed well with the chemical properties when taking sub-samples from every loaded spreader when spreading. An alternative procedure for taking samples is to place collectors on the ground before spreading manure. The recommended rate of solid manure in tonnes per hectare is in Sweden based on the con-tent of P and also on a maximum recommended application rate at each spreading time 15]. The regulations in Sweden regarding maximum livestock density are based on a supply of phosphorus to the crops of 23-25 kg per hectare and year [6].

3. Spreading techniques on the market

Most spreaders on the market are rear discharge spreaders but, for example, in UK side discharge spreaders are mostly cornmon [1]. In general, a solid-manure spreader consists of a moving floor and a spreader device. The spreaders are, depending on the spreader device, divided into one- and two-step spreaders [7]. With a one-step spreader both shredding and spreading is done with the same device. With a two-step spreader one device shreds the solid manure into pieces and another spreads the manure to the ground.

Methods have been developed for testing of manure spreaders for environmental safety [8]. A test plant has been built outside Uppsala. The testing of manure spreaders is divided into delivery rate tests and transversal tests. The delivery rate tests give information about the application rate at different settings of the delivery device on the spreader. Also, the tests register the spreaders capacity to maintain the set rate during the delivery process and give guidance on a suitable driving technique for spreaders that in a systematic way will deliver different rates during the process of unloading. The transversal tests give information about the acceptable working widths for solid-manure spreaders. The evenness of spreading, often presented as coefficient of variance (CV), depends on the test method used. Therefore, a standard method for testing is desirable to be able to compare test results from different test plants.

3.1. *Delivery rate tests*

Manure spreaders are often incapable of spreading solid or semi-solid manure evenly over the field. Test results show that uni-form unloading of the manure is only obtained on less than half of the length of the bout, when the moving floor of the spreader as well as the tractor are driven at a constant speed (**Fig. 2**) [9].

At the start of the unloading, the discharge flow is normally low. The reason is, that manure cannot be loaded right out to the beaters without risking blockage. After a while, the unloading is gradually stabilised at a uniform and high level when the beaters are working at full load height. Owing to friction between the manure and the sides of the spreader, the load is gradually torn apart. With solid manure, the moving floor travels a distance corresponding to about 1.3 lengths of the spreader before it is almost completely empty. With less solid manure, the moving floor must travel an even longer distance. At the end of unloading, the height of the load has decreased, with the result that the application rate per time unit decreases. When most of the load has been spread, the height of the load has decreased so that some of the manure starts to be thrown back onto the spreader since the load does not give any resistance. The last 5-10% of the load will take too long a time to spread.

3.2. *Transversal tests*

The rear discharge spreaders with scraper-floors and horizontal beaters for applying solid manures have small working widths and also low efficiency. Two-step spreaders, with an unloading unit consisting of beaters and horizontal spreading discs often have a larger working width. Spreaders usually have two or four discs. The result of DLG-tests presented by Döhler [10], **Table 1**, shows that, under optimal conditions, the precision of transversal distribution achieved by these spreaders is accept-able. The optimal working width was between 7 and 12 m. The longitudinal variation was also acceptable at this low rate, 10 tonnes per hectare, but at higher rates the precision decreased.

3.3. *Influence of manure properties on test results*

Manure properties affect the performance of manure spreaders [I1]. Different spreader types are influenced in different ways when manure properties change. The bulk density can be concluded to affect important spreading parameters such as the steady flow and the optimum working width. **Figure 3** shows an example of the relationship between bulk density, setting of the speed of the bottom conveyor and "steady flow" of manure for a JF ST70 IT This shows that the physical properties of the solid manure should always be presented together with the test results.

3.4 *Influence of the tractor driver*

Even the most sophisticated machines often rely on driver accuracy, especially in bout matching, if they are to achieve high levels of precision during spreading. In the future, this may necessitate fixed width spreading machines that can be used with tramline systems. However, solid manure is often spread on arable land where tramlines are not used, thus an alternative tool must be provided to improve driver accuracy. Global Position Systems (GPS) could be used for this.

3.5 *Other aspects on spreading results*

It is important that solid manure is finely scattered when applied to growing crops and especially on grassland. A method for image analysis and a computer program has been developed for analysing photographs of a white surface where manure has been applied [12[. The result from the image analysis is presented in numbers on a scale from 1 to 10, where 1 is the best degree of fineness and 10 the poorest. This test method has been used in official tests in Sweden and also in research [7].
Solid manure can give rise to substantially greater ammonia emissions than slurry when applied at the same rate under identical environmental conditions 113]. The conclusion is, that solid manure should be incorporated soon after spreading. So far, there are no "injectors" for solid manure on the market.

4. Development to improve the evenness of distribution

4.1. Longitudinal distribution

At JTI, work has been done to improve the longitudinal distribution of solid manure by spreaders equipping the spreader with a movable front wall and a controlled speed of the moving floor [14]. The torque required to run the beaters controls the speed of the moving floor. In **Figure 4**, the curve of discharge rate is presented with the torque of the beaters.
With this equipment, a nearly constant application rate all along the entire bout is achieved (**Fig. 5**). Present research at JTI is aimed to improve a spreader for semi-solid manure in the same way.
The company Walterscheid has used the principle to measure the torque pickup of the withdrawal and/or spreading equipment and to maintain this constant by regulating the speed of the scraper floor. This system has been on the market for some years. So far, no official tests have been presented.
In UK, a control system has been developed [15], which is also based on torque sensing of the discharge aperture. This system is implemented on a side discharge spreader where it is integrated with control system of the tractors and controlling the spreader discharge aperture and forward speed. The development work is done in co-operation with an agricultural machinery manufacturer.
Instead of torque sensing a weighing platform has been used as weight sensor by CEMAGREF in France [16]. The floor of the spreader has been cut up in the rear and the weighing device has been placed inside this cut out. To obtain a regulation, it is necessary to calculate and adjust the correct velocity of the moving floor in accordance with the desired discharge rate. The integrated weighing platform system has been patented and a manufacturer will develop a regulation device.

4.2. *Transversal distribution*

The longitudinal distribution can also be improved by installing dosing augers behind the beater rollers, which allocate a de-

fined quantity of the material to the broadcaster discs as a function of the engine speed 117]. At the University of Kassel [18] this development was combined with broadcasting discs mounted on booms specifically to apply composts. The decentralised arrangement of the broadcaster discs counteracts inaccuracies in the distribution resulting from the increased wind susceptibility of the material (composts) being applied.
Economy

5. Economy

comparisons between manure handling systems showed that an improved uniformity of application was more profitable on a slurry spreader than on a solid-manure spreader, because of the more homogeneous distribution of nitrogen in slurry and the lower amount of plant available ammonia nitrogen in solid manure [19]. The value of improved uniformity of application was also compared with an increased working width from 5 to 12 m. A broader working width was a more profitable measure to take due to reduced soil compaction.
Slurry systems will generally give a higher utilisation of plant nutrients than solid manure systems. Solid manure systems are more profitable than slurry systems for small dairy farms.

6. Need of research

In the survey [1] serious gaps of knowledge were identified, e.g. factors controlling sol-id manure composition, nutrient availability of solid manure (especially for nitrogen), long term efficiency of the nutrient cycle in solid manure farming systems.
A good agricultural practice demands systems for spreading of manure with high precision, high plant nutrient utilisation, and minor wheel damage. Further development is required before this is achieved with solid-manure spreaders.

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Fig. 1 - Manure classes for non-pumpable manure [2]

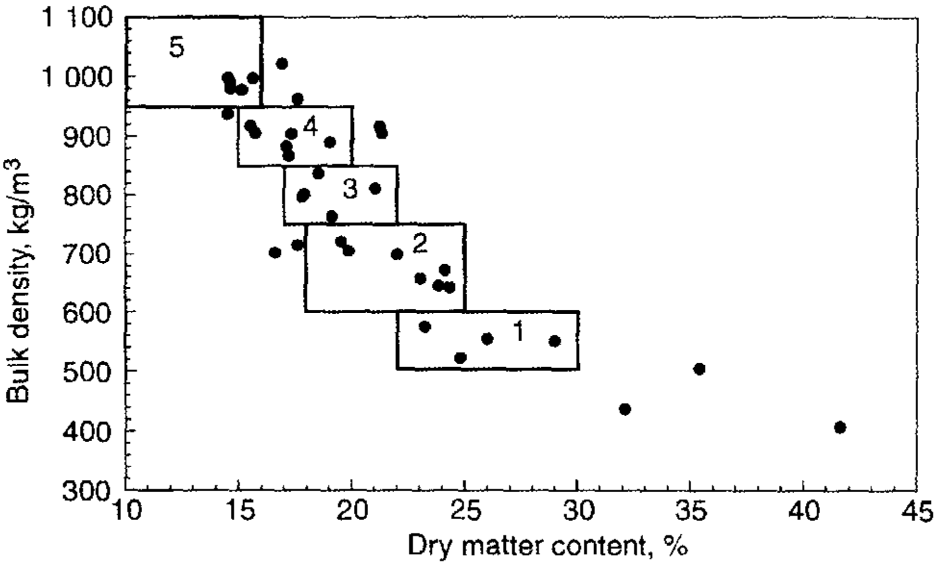

Fig. 2 - Typical unloading curves for a fully loaded spreader with moving floor [9]

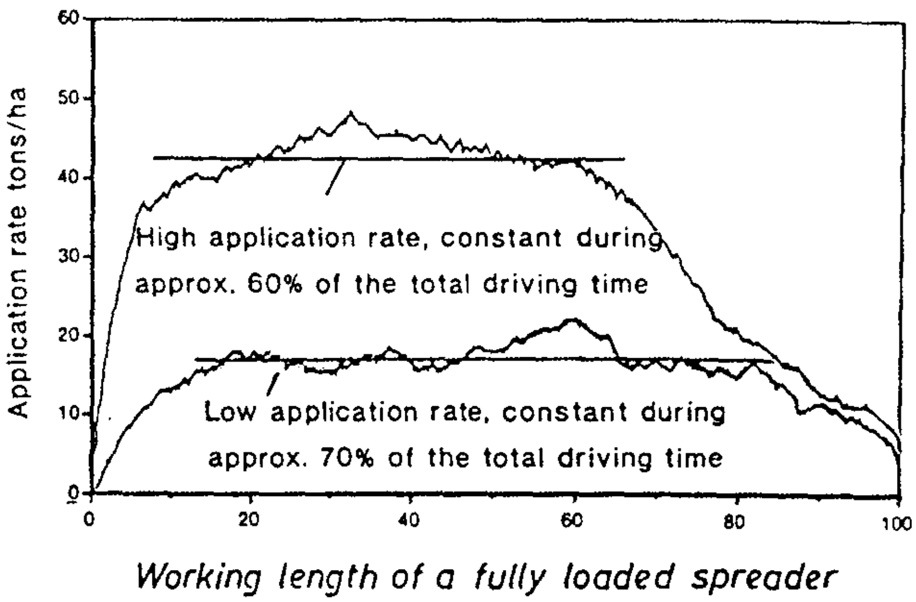

Fig. 3 - The relationship between bulk density, setting of the speed of the bottom conveyor and "steady flow" of manure for a JF ST70 H [ll]

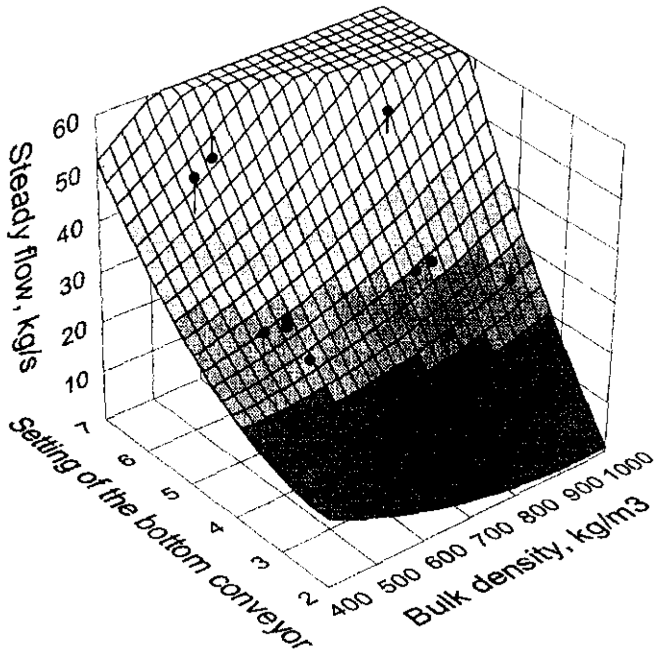

Fig. 4 - An example of a discharge curve and the corresponding torque for the beaters when spreading solid manure with an ordinary spreader with moving floor [13]

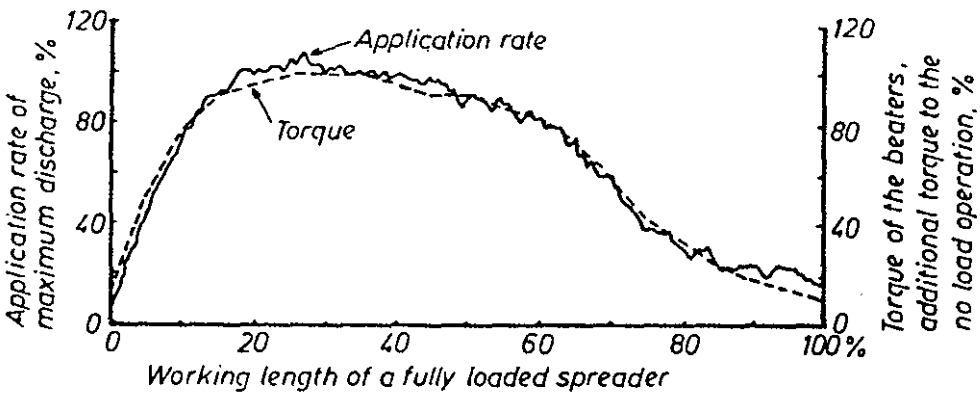

Fig. 5 - Unloading curve with the torque regulation system [14]

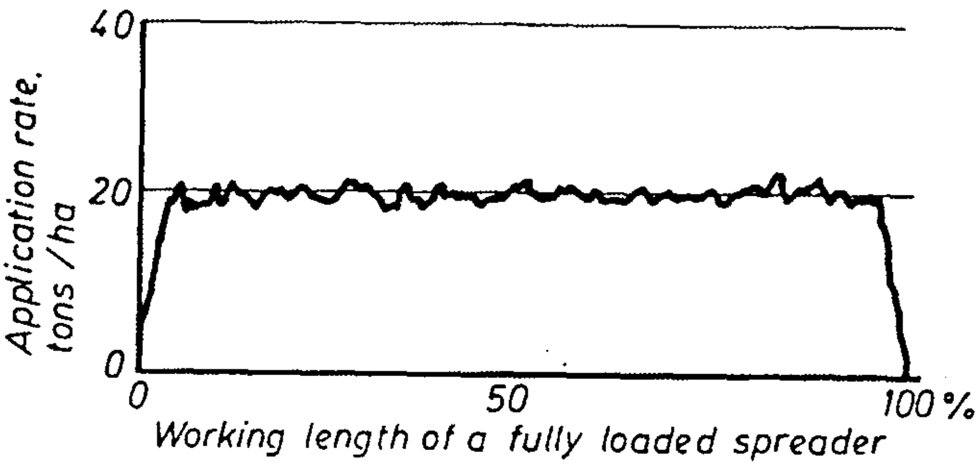

Table 1 - Transversal and longitudinal precision of distribution of solid-manure spreaders presented as coefficient of variances (CV) at a rate of l0 tons/ha [10]

MANUFACTURER	TRANSVERSAL DISTRIBUTION (OPTIMUM WORKING WIDTH)		TRANSVERSAL DISTRIBUTION (TRAMLINE DISTANCE)			LONGITUDINAL DISTRIBUTION
	(m)	(CV, %)	(9 m)	(12 m)	(15 m)	(CV, %)
Bergmann	8.5	28	30	35	43	17
JF	8.0	9	12	18	24	23
Strautmann	7.0	7	10	18	38	12
Tebbe	11.5	10	12	12	23	13
Webster	10.5	22	25	25	35	8

DISCUSSION

John SCHUELLER

USA

My question is to Prof. Sangiorgi: in order to ensure uniformity we should have agitation or steering on the slurry spreader and probably on the source in order to get a uniform mixture to spread. How can we sense the slurry quality, how can we control the quality and when do we start to have a control system?

Franco SANGIORGI

If you mean for the evenness of spreading, agitation or steering, I'm sure it is of paramount importance, but we shall consider two scenarios: one is agitation and steering into the slurry tank, which means I shall take this slurry, which has already been agitated, using different devices. If I load a slurry tanker I must take into consideration the distance between the slurry storage tanker and the field where I'm to spread the material, because, for certain types of slurry, the rate of separation between solids and liquids is very fast - as with pig slurry - while the ideal situation is to have on-board steering devices. The second question is how to make a system that can be self-adjusted during the working phase; this means how to adjust the quantity of slurry to be spread in relation to its characteristics. We have just heard that in Sweden there is a maximum limit of total slurry, or phosphorous, that can be spread per hectare. So you can consider two types of devices: one that just controls the quantity, (this is a question of regulating valves etc.); in the second case if you add a nutrient limit factor then you have to include some sensors for controlling the total amount of phosphorous, nitrogen and so on. Then you have to regulate the tooth valve opening in order to maintain in real time the distribution of nitrogen in relation to the exact amount of nitrogen content at the moment of distribution. Devices were developed under the SWAMP project, promoted by the European Union, in which different countries took part: the Silsoe Research Institute, Teagasc in Ireland and a Dutch team, chaired by Dr. Jan Huijsmans etc. These devices were based on conductivity and on the measurement of slurry density; through which it was possible to determine, with a certain degree of accuracy, the nutrient content of the slurry. This enables us to develop a self-regulating system during the spreading phase.

Axel MUNACK

Germany

I would like to draw your attention to control via flow branching. This is a common practice in Germany, whereby you have a pump which redirects part of the flow into the tank while you play the other part. This enables mixing to take place during application in that some of the slurry is fed back, and also provides a very fast means of control. The other point is that you are very much in favour of injection techniques, because of a reduction in the loss of ammonia. I think there are some objections against that, because if you inject under extremely unfavourable conditions, you dramatically increase nitrogen leaching. I think a good compromise is not to inject, so as to reduce ammonia emission and thus avoid a dramatic increase in nitrogen leaching.

Franco SANGIORGI

The question is that a three-valve system can be utilised only if you have a positive pump on board. As I tried to illustrate, in our country the number of manufacturers adopting positive pumps is very low. Currently they do not have the experience or the market demand for a better system to control the total amount of slurry to be spread. I heard Dr. Rodhe talking about 30 cubic metres per hectare; often in our country 300 cubic metres per hectare and more are spread. So you have to consider that there is a different approach: you don't just need to regulate, you also need a big pipe in order for the fastest possible slurry dis *charging. However, this is a question of dilution. In our country we use a highly diluted slurry, while in northern Europe they generally have highly concentrated slurry. I am not in favour of the injection technique, I am in favour of a system that can be regulated in relation to the different agronomic needs and to the different weather conditions. I fully agree with you, Dr. Munack, that there are quite a few problems with the injection technique - it is just another technique that can be utilised. I've tried to illustrate the famous Teselius catch on the different type of equipment, but what is important is that the farmer should have a type of software that can help him make decisions, both of strategic and tactical nature.*

Malcolm McKAY

Australia

I think that the issue we were talking about, of trying to measure in real time each concentration, is an excellent approach. I think that in our country we try to convince farmers to understand what the nutrient content of the waste is. It is a long, long way from having a control and an understanding of what the nutrient content actually is. The comments about the desire of farmers to have wider distribution do not surprise me at all. I think it is characteristic - we want the ground regularised quicker and faster. Given that the soil waste is such a heterogeneous mix , one of the techniques for soil is to chop it up as finely as possible, and then get a wide distribution. My question is for the second speaker: what is the potential for segregation of the material? You are getting an equivalent or, may be, even a mass distribution, but in terms of nutrient contents it may be quite different; in other words, little components, which you said are in co-operation with the manure, have different distribution characteristics to nutrient-carrying components.

If you chop up primary within the spreader and then you try to distribute the long way, the changes for segregation, due to the different physical characteristics, can become some task. So, you can have the manure components, the nutrient-carrying components, with different distribution compared to some of the other components, so you are in co-operation with a transversal distribution and this may be quite different in terms of nutrient distribution.

Lena RODHE

Perhaps you could have run some additional transversal tests on this, testing the content too, but in that case we wouldn't have seen any difference. I think that if you have a low bulk density, fairly fresh manure with fresh straw, you obtain segregation, so you must continue along this line.

Francis SEVILA

France

I want to congratulate both speakers on the quality of the speech and Dr. Rodhe in particular, who mentioned the state of the industry and of research. I refer to both your conclusions, which focused on the agronomic interest in manure. In one case you optimise, in the other case you just try to reach a specific solution and this should be a small aim for agriculture, because you only discussed animal waste manure. In some areas of world agriculture may play another role in trying to help industry or urban areas eliminate solid organic waste. So, my question is: have the technologies you mentioned been considered for all types of solid, organic waste management? Is there any specific problem to be mentioned in relation to this?

Lena RODHE

Are you referring to the compost spreader, which has a very low bulk density? We conducted tests using ash, a very light material. You try to use technology already utilised for solid manure: sometimes you find spreaders which are useful and sometimes ones that are not. Consequently, you need to make improvements or changes. Returning to agricultural waste, you have to consider additional factors, for instance, that today there is *a market price for manure and when it must be distributed at a low rate – sometimes as little as 2 tonnes per hectare – solid manure spreaders are not good enough. On the other hand, there are some dried pellet spreaders which distribute many fertilisers in a random way; in general, at an output which is far too low, leading to uncovered spots. In any case, from a scientific point of view, by flow branching the physical properties of the fertiliser, you should be able to obtain the right type of spreader.*

Karl Theodor RENIUS

Germany

I would like to make a comment and put a question to Prof. Sangiorgi. I think the inflation pressure control systems are very important, as in the Netherlands, as you mentioned. However, they do not only address soil compaction, but also the reduction of pull force. Many contractors are motivated to introduce these systems, which are very expensive (around US$ 10-12.000 per unit) but can have a pay-back period of 2-3 years. In my opinion the injection system is extremely environment friendly, but it does have some problems, these mainly regarding high pull force and contact with buried stones. Could you give us your evaluation on such a type of system?

Franco SANGIORGI

The question of pull force reduction is an important side effect of using low pressure tyres with an option of changing the pressure under different working conditions. The market trend in the Netherlands, for instance, and in Italy too, is towards contractors, the large self-propelled machines, in order to carry up to 30 cubic metres at a time. Injection is one of the systems to be considered; for instance, in Italy, we have 10 months, from February up to December, called "spreading window". In that period slurry must be spread, but different weather conditions, crop presence and crop growth all have to be taken into consideration. At different times of the year you have to choose the best equipment and the best spreading device. What's required is a polyvalent slurry tanker with different types of spreading device which can be used in relation to the particular conditions at the time of the operation. As regards the high pressure injection system, it seems to be very interesting, but still in an experimental phase and currently without market prospects.

Lena RODHE

I have some comments on pressure injection. Last summer, within heavy soil and in very dry and hot weather conditions, we carried out several tests using a high pressure spreader; we also used another injection system with tines. Neither of the techniques made it possible to inject slurry into the soil.

Franco SANGIORGI

We have to take into account that the problem is highly country specific, because only with concentrated slurry is it possible to use "state-of-the-art equipment"; with a very diluted slurry it is not possible. It is for this reason that there is a question of local market.

Jurgen HELLEBRAND

Germany

Dr. Rodhe mentioned that one difficulty in spreading is the high degree of heterogeneity of the manure. Obviously, this is true with fresh manure, but usually manure must be stored and composted, because of the impossibility to distribute it all the year round. Nowadays, there is a lot of debate on the fact that aerobic treatment is responsible for environmental loss and that it leads to soil mineral loss; therefore, there is an attempt to introduce into the debate the use of the anaerobic treatment that changes the physical properties of the material. What happens when anaerobic digestion is applied to the manure the during application or spreading operations?

Lena RODHE

As regards composting, we studied the use of horse manure in fields, in spite of its high straw content; other materials such as peat, which is very good for retaining ammonia, were also tested. The composting process can be improved by covering the heap with waterproof materials to prevent rainwater from entering and removing the nutrients as it runs through. As regards anaerobic treatment I believe you have to mix and dilute for using in the digesters. We have no experience on solid digestion.

Franco SANGIORGI

In the storage tank there are anaerobic conditions, so it is rather difficult to consider slurry. We are talking about liquid slurry here, not the sludge that comes from anaerobic installations. Liquid slurry is very similar to the product that comes from a storage vessel where slurry is preserved for at least 180 days; however, if you have an anaerobic installation with a controlled process, you can obtain sludge, similar to the one coming from the treatment plants. As regards the question of distribution, we need a totally different approach in order to maximise the use of agronomic slurry. It means that the farmer should be supported and given information on how to work and spread the slurry in all environmental conditions. At present there is no experience on slurry management in that it is a "new material" for farmers. In fact, until 40 years ago slurry was absolutely unknown and the first stabling system appeared only towards the end of the 1990s. Given this lack of experience we need to give input to farmers for an improved use of this material.

Arturo LARA LOPEZ

Mexico

These advanced technologies discussed by the speakers are appropriate for developed countries; but, perhaps for developing countries they might have an equivalent in small-medium sized equipment. Have you any comments on this ?

Franco SANGIORGI

To solve the problem it is better to return to the origin. In actual fact, by using appropriately run cattle or animal rearing facilities you can easily solve the problem of a good relationship between the animal load and manure, or slurry, produced. In this way you can also utilise simple, as opposed to sophisticated systems. However, in this case, you have to deal with heavy pollution. To solve this problem, it is necessary to introduce technologies that are incompatible with the farmer's requirements.

Richard O. HEGG

USA

I want to make a comment based on the USA experience concerning the large animal feeding operations and the concentration of manure. There is a quite strong trend to move towards a nutrient management plan, which is required sensibly from a lot of operators. Industry amplified in this group the need to have engineering to solve this aspect: talking about the nutrient management plan, we are very good at measuring what the crop needs, what's in the soil. Returning to the applications presented by the two speakers, the application of the manure nutrients at the proper rates and using the right controls requires slurry engineering implements. In my estimation the situation is even at a crucial state, we have a long way to go to make this an ideal system. So when do you predict we will have some of the sensor control mechanisms in place to really improve the quality of the nutrient application?

Lena RODHE

I think as soon as it is brought in it will be on the market, but, as I've said, the profitability of the technology for solid manure is hard to envisage today. Perhaps not for slurry, for which it's easier.

Franco SANGIORGI

We expect in a couple of years to be ready with something marketable from online sensors.

Pawel KIC

Czech Republic

In the second paper it was mentioned that the Czech Republic is one of the countries ready for the application of solid manure. I would like to explain a little bit our traditional system. It has been seen that, especially in the area of cattle breeding, we use straw bedding which is particularly suitable for animal welfare. Even over the last 10-15 years with the renovation of many stables we have used the straw bedding stall system. We realise that it's better than using the solid manure for soil quality and structure and last, but not least, for the problem of water protection in the earth. We recognise that there are differences in the use or in the potential use of liquid manures, especially in different countries as in the EC. I think the question of participation within the EC by neighbouring countries is important to solve this issue, as is the legislative aspect. I would like to know how legislation is handled between the different countries, and if there's a law valid for the European Community?

Franco SANGIORGI

As regards the use of straw, we try to reintroduce it into many of our livestock facilities, although its use is unsuitable for certain types of end production such as ham which cannot be produced with straw bedding. In other types of production there is a correlation between straw production and livestock facilities. In Italy straw is produced mostly in the southern part of the country, so it becomes uneconomical to use it because of the transport costs. Straw handling is generally a very costly issue on the farm. The second issue regards environmental protection linked to the use of slurry as a non-pollutant source. Unfortunately agriculture becomes a source of pollution through the need to fertilise the soil and these fertilised soils in some way pollute the water. This situation depends on the fact that to produce more you have to apply more fertilisers, which cause pollution. This problem can be partially controlled by an integrated system and solved by considering all the factors together - weather conditions, soil conditions, crops and so on.

Derek SUTTON

U.K.

In modern repopulated countries like the UK, the public perception of pollution and particularly the negative public reaction to "not good smell" is a strong driving force for both research and legislation. Is it the same in other countries? Second question is: in connection with not good smell problem, could the speakers just summarise the methods which are the most appropriate for minimising that particular issue?

Lena RODHE

I think that odour coming from ammonia emissions is a big problem, but if you could cover the storage and incorporate slurry, you could drastically reduce the odour. Also the land structure is an important factor; for example there are more complaints if farms are located near urban areas. In Sweden this problem does not exist, because we are so not densely populated and when a farmer wants to expand his stables, he has to have special permission.

Theodor FRIEDRICH

FAO

I've only one comment about the point raised by Prof. Sevilla and Prof. Hellebrand. I appreciated the up-date on the development state of the technologies we have. I wonder whether this is the real background issue, whether we are not facing another set of problems behind these technical issues, for example the production and structure concentrations that force us to introduce technical solutions. I wonder if this Club of Bologna *should focus on technical detail solutions into the local aspect of production structure policies, including different methods of processing waste and giving some guidelines in this direction. We are not only talking about animal waste, but also of integrated agriculture, and the whole concept of waste management includes other types of waste. This is why we must not only to take into account the technical details of the gadgets and equipment.*

Franco SANGIORGI

I can take this opportunity to tell you that next year, at the end of August, we will be holding a meeting to discuss this particular topic. This Meeting is promoted by RAMIRAN, a regional organisation under the auspices of the FAO.

Yoshisuke KISHIDA

Japan

I have a comment to make on the new machines for manure distribution, particularly with regard to paddy fields. In Japan a farmer has to raise crops and attend to animal husbandry. Usually after harvesting, the soil in the paddy fields is very soft and not good for machines. The new machines are a self-propelled truck-type manure spreader and a truck designed like an automobile. These machines are equipped for dealing. The second machine can go through the high-way and at the same time is very good in case of difficult weather conditions. To solve traffic ability and compacting problem using this kind of technology and machines will be helpful for other countries.

Advancements on the technologies for inputs distribution: the case of solid mineral fertilizers

by **Paolo Balsari**

Italy

1. Background

Starting in the '50s, and partly thanks to the availability of low cost chemical fertilizers, there was a considerable increase in agricultural yields. This was especially true in the more industrialised countries, and made it possible to meet the increasing domestic demand for food products which resulted from the demographic explosion of those years. Up until the end of the '80s, the low market price of mineral fertilizers, coupled with the great increases in yield achieved through their use, translated into what was often an agronomically incorrect use of these chemical products, together with largely inadequate application methods and techniques. The European Union has estimated at approximately 1 million tons per year - or 0.5 billion Euro - the quantity of nitrogen that fails to be used by crops due to incorrect application. In Great Britain alone, this type of waste is estimated at over 80 million Euro [1]. The machinery industry, too, tended to neglect this particular sector of agricultural mechanisation. The machines developed were low cost designs of simple construction. The users, on their part, did not demand technological innovations from the machinery industry, due to the low incidence of mineral fertilization on production costs. In fact, the considerable benefits in yield obtained through the use of chemical fertilizers were often sufficiently large to mask - from the economic standpoint - the negative effects of their non-uniform distribution. All this translated into the creation of an inefficient machine base and undesirable product wastage. In a study conducted in Italy on over 20 different spreaders [2] approximately 40% of this type of equipment was found to be over 10 years old and over 75% was operating with inadequate uniformity of transverse distribution (CV greater than 20%) (**Fig. 1**). The effective application rates were characterised by errors of between -36% and +23% with respect to the target rate (**Fig. 2**).

At the beginning of the '90s, starting especially with the Northern European countries, there was an inversion in this trend, spurred by the need to reduce production, cut costs (fertilizing accounts for approximately 20% of variable costs), safeguard the environment and improve operator safety, all of which led the manufacturers to develop new equipment for the distribution of mineral fertilizers (**Fig. 3**).

In particular, the development of the new technologies was driven by the need to improve the following aspects of the distribution of mineral fertilizers:

- quality and quantity of work;
- ergonomics and operator safety;

which proved to be, in turn, mainly connected with the need to comply with a series of environmental and safety regulations.

Partly as a result of the different time-scales for the enactment of the relevant national laws and the adoption of European or international regulations, the technological level of the installed machine base in this sector varies considerably from country to country. The countries of Northwest Europe were undoubtedly the first to develop technologies which addressed the above-mentioned aspects of environmental protection and operator safety, also thanks to their greater awareness of these issues.

A very different situation exists in the Mediterranean and Eastern European regions where, with the exception of a few large-scale farms, traditional single spinner spreaders continue to be used, resulting in non-uniform distribution of agronomically incorrect application rates.

2. The technologies developed

Electronics has played a fundamental role in the development of new technologies aimed at improving the quality of mineral fertilizer application and safeguarding the environment.

It has first of all made possible the control of a series of spreader operating parameters and the incorporation of this functionality into a computerised farm management system (CAF - Computer Aided Farming), as well as the subsequent performance of precise and targeted fertilization as a function of crop yields (Precision Farming).

Electronics has also made it possible to address the other operating requirements mentioned above and connected with the evolution of these machines, for example by enabling the development of remote controls and spreader calibration systems with varying degrees of automation.

2.1. Quality and quantity of work

There are two types of error which the operator can make during the application of mineral fertilizers: an incorrect application rate, and an insufficiently uniform distribution. In the first case, the cause is often incorrect adjustment of the spreader, while the second case is attributable to an incorrect choice of working width, or to the use of unsuitable fertilizers or machines.

Non-uniform fertilizer distribution affects crop yield in different ways, which are closely dependent on the type of fertilizer used, the concentration of nutritive substances in the soil and the target level of fertilization. With phosphorus and potassium, these errors do not translate into considerable variations in yield (soils, with the exception of those particularly rich in limestone, are generally well provided with these elements which are fixed by the organic and mineral colloids of the soil, and are thus available over time). However, in the case of top dressing with nitrogen fertilizer, the yield can be irremediably compromised by non-uniform distribution. In general terms, uniform distribution is especially important when working on soils with low nutritive content, when performing nitrogen top dressing, and with high application rates of mineral fertilizer. In fact, in the case of low nitrogen rates (typical, for example, of meadows with crop rotation) the increased yield of the excessively fertilized areas compensates for the lower yield of the under-fertilized areas (**Fig. 4**), but on the other hand, with a high nitrogen rates (for example as in cereal crops) this compensation does not take place, and there is an overall reduction in yield.

The development of pneumatic spreaders in the late ‘70s unquestionably contributed to improving the quality of distribution of these chemical products (highly uniform distribution under all operating conditions, particularly near the field boundaries, generally independent of the physical characteristics of the fertilizer, ease of machine adjustment and determination of the working width). However, their adoption on the European territory remains very limited (today they do not account for more than 1-2% of the installed machine base). This fact is attributable to their higher market price as compared with centrifugal spreaders, especially (+100%) in the case of machines with very low working widths (12-15 m), to the impossibility of matching the working widths obtainable with centrifugal spreaders (for reasons of stability and constructive complexity, the maximum working width of pneumatic spreaders is 24 m) and, finally, to the need for frequent and costly servicing.

In consequence, the manufacturers focused their efforts on the development of centrifugal spreaders that could ensure good uniformity of distribution, in both the transverse and longitudinal directions, under nearly all operating conditions and, most importantly, with large working widths (up to 36 m), in order to increase their work rate. The need to operate with large working widths has also hindered the development of oscillating spout spreaders, which have a maximum working width of 18 metres.

To achieve these objectives, a number of design features have been incorporated into centrifugal spreaders, including:

- the possibility of continually and separately adjusting the rotation speed of the two spinners, via their hydraulic drive (**Fig. 5**);
- special metering devices installed on the spreader (volumetric or gravimetric feeders, with electronic adjustment of the hopper outlet opening) (**Fig. 6**);
- the use of specially shaped distribution spinners, fitted with blades of different shapes and lengths, whose position relative to the spinner itself is adjustable (**Fig. 7**);
- the possibility of varying the drop point of the fertilizer on the spinner (**Fig. 8**) by shifting the position of the spinner relative to the fertilizer outlet on the hopper, or by shifting the drop point of the fertilizer relative to the spinner.

The use of these technologies also makes it possible to optimise the application near the field borders and the perimeter of the tilled area. This is especially important when fertilizing small fields, which have a high border-to-surface ratio. The solutions to this problem differ depending on the chosen operating method: distribution from the tramline, or with a spreader pass near the field border (**Fig. 9**). In the first case, special distribution spinners (**Fig. 10**) and/or special guards (**Fig. 11**) are used to reduce the maximum fertilizer throw range, thereby obtaining a distribution pattern that does not require overlapping — or the height of the spreader relative to the ground is automatically varied (**Fig. 12**). In the second solution, which is suitable for all working conditions, only the spinner on the side facing the centre of the field is used, with partial shielding or inversion of its rotation.

These adjustment systems can also be combined with electronic application rate controllers which, when equipped with additional sensors, can also provide the operator with data on the fertilized surface, the actual application rate, the instantaneous ground speed (**Fig. 13**).

Electronic application rate control systems can be used for implementing precision agriculture, or where the fertilizer application rate must be varied within the field, as a function of the soil yield potential soil. These differentiated fertilizing systems can be classified according to the methods used for determining and distributing the target application rate on each unit of surface [3]: the creation of a fertilization map followed by geopositioning-assisted application (mapping system) (**Fig. 14**), real-time systems (real time sensing and application) which use a sensor to measure the light reflection factor of the crop in order to determine its chlorophyll content, and on the basis of this data perform targeted real-time distribution of the fertilizer (**Fig. 15**).

Although pneumatic spreaders are more suitable for differentiated fertilization (the application rate is more easily adjustable, and on smaller sized surfaces) [4], virtually all Precision Farming applications to date have chiefly focused on centrifugal spreaders, due to their constructive and functional characteristics and - as mentioned above - their low cost. In short, the contractors, who are currently the group most interested in implementing differentiated fertilizing, want to operate with greater working widths than those obtainable with pneumatic spreaders.

The adaptations of centrifugal machine designs to permit differentiated fertilizer application have principally concerned the hydraulic drive of the two distribution spinners - to allow variation and control of their rotation speed - and the adjustment of the opening at the base of the hopper by means of hydraulic jacks [5]. However, these technical solutions have two types of drawback: the need to re-adjust the spreader whenever a product with different physical characteristics is used, and the necessity of operating with a distribution grid front of predetermined size (otherwise, the uniformity of transverse distribution is altered) and considerable depth (over 5 metres). This means that the grid resolution which can be effectively used for differentiated fertilizing is considerably greater than that used to create the fertilization map [6]. In fact, such maps are generally constructed on the basis of the yield map, whose grid size is equal to the working width of the harvesting machine (6-8 m).

2.3. Ergonomics and operator safety

The developments in spreader construction relating to ergonomics and operator safety were initially aimed at compliance with specific national regulations, and subsequently at compliance with the EEC Directives 89/392-91/368-93/44 and 93/68, while in the short term it will be necessary to conform to the prEN 1553-1 and prEN WI 144044 standards (**Table 1**).

In short, the developments aimed at improving the ergonomics and safety of spreaders can be summed up as follows:

- addition of guards on the spinner discs which, without obstructing the trajectory of the fertilizer granules, prevent accidental contact between them and the operator;
- remote metering of the fertilizer flow from the hopper, with the possibility of controlling the fertilizer distribution directly from the driver's seat;
- simplification of the mechanisms for adjusting the application rate, and their positioning in sufficiently protected areas well away from moving parts;
- development of tilting hoppers fitted with protection grilles, and which are easy to fill (loading height not greater than 1.5 m), or of special accessory equipment for the mechanical handling of the 500 kg sacks.

3. Prospects for the future

The future evolution of machines for mineral fertilizer distribution will increasingly be driven by the need to comply with the existing regulations with regard to environmental protection and the health and safety of the operator, as well as by the need to contain production costs. These needs will also influence the manufacturers of mineral fertilizers, orienting them toward the production of safer fertilizers, especially in terms of environmental conservation. In particular, we note the increasingly stringent regulations on the use of nitrogen fertilizers, which place restrictions both on the application rate (related to the vulnerability of the soils) and on the distribution method (containment of leaching losses and loss of nitrogen in ammoniac form). In fact, this fertilizing agent is one of the most commonly used in Europe (on average, approximately 90 kg/ha year) (**Fig. 16**), especially in the Netherlands (220 kg/ha year), Germany and Denmark (FAO Fertilizer Yearbook), and it is also the one which poses the greatest environmental hazard (the fraction dispersed in the environment is generally between 10 and 40% of the total quantity applied).

To address these problems, the chemical industry has in recent years produced fertilizers based prevalently on nitrifiable nitrogen in stabilised ammonia form. These differ from traditional nitrogenous fertilizers in that they contain a substance which inhibits nitrification, thereby slowing down the natural transformation of ammoniac nitrogen into nitric nitrogen, through a selective activity on the nitrifying bacteria for a period of 4-8 weeks.

This makes it possible, for a certain period of time, to maintain the nitrogen in ammonia form, which resists washing from the soil even after plentiful precipitation [7], as well as minimising denitrification phenomena and, for a few weeks, the emission of NO_2 and NO_x into the atmosphere [8, 9].

So far, these types of fertilizers have only been widely adopted for horticultural crops, due to their higher cost (up to +100%) compared to traditional nitrogen fertilizers. However, we believe they can also gain wide acceptance on arable farms, by virtue of the yield increases which they appear to provide (+8-10%) [10] (**Fig. 17**), and hence their superior productive efficiency, as well as the possibility of reducing the number of applications (one is often sufficient).

The anticipated adoption of these types of fertilizers will translate into application methods which take place mainly at the time of seeding, making it necessary to increase the capacity of the fertilizer hoppers on the seed drills or combined machines. In such a scenario, the main problem would no longer be the uniformity of distribution, but rather that of having the same operating range as the implements (seed drill and sprayer) without excessively weighing down the assembly and creating soil compaction problems.

In short, the prospected future situation will be differentiated as a function of the types of regulations in force and the type of fertilizer that is distributed.

The countries most subject to statutory restrictions on the use of mineral fertilizers may see an increased adoption of electronic systems for adjusting and controlling the application rate with real-time geopositioning. This last-mentioned feature will be used to determine in the position of the spreader in real time, thus conforming the application rate to statutory restrictions (for example, the vulnerable areas set out by the EC Nitrate Directive) and, used in conjunction with a system for monitoring the spreader's operating parameters (real-time system with map-overlay), for certifying compliance with the regulations in force. Initially, this type of technical solution will chiefly interest contractors, for whom it is extremely important to obtain real time information to guide the application of mineral fertilizers. On the other hand, the use of geopositioning for site specific chemical fertilizer application guided by a mapping system is expected to be less widely adopted, because this method requires the compilation of fertilization maps, drawn up on the basis of criteria that are as yet poorly defined, depending as they do on many unpredictable variables (effective investment, amount of precipitation, level of weed infestation, presence of parasites, etc). A more interesting implementation of this targeted fertilization method is the use of the systems mentioned earlier, which are able to determine the amount of chlorophyll in the crop to be fertilized and, as a function of this, to adjust the spreader in real time for an appropriate fertilizer application rate.

This last mentioned solution is one which, at present, concerns nitrogen fertilizers almost exclusively. In order to improve their utilisation by the crop, thus reducing costs and environmental pollution, nitrogen fertilizers shall in future have to be distributed in different solutions for top dressing and, in the case of hoed crops, only in a localised manner, and possibly by incorporating them into the soil. Potassium and phosphate fertilization, as well as fertilization with micro-granules, will continue to be performed prevalently during the pre-emergence stage, and preferably during seeding.

A wider adoption of slow acting nitrogen fertilizers will further promote the solution of distribution fertilizer at the time of seeding, spurring the development of dedicated machines, also equipped with geopositioning systems to facilitate compliance with statutory restrictions and optimise the application rate.

Therefore, in the more technologically advanced countries, an evolution of these types of machines is expected to take place over a number of stages.

In the short term there will be further developments in electronics, geopositioning systems and systems for on site and real time determination of the application rate, used principally on centrifugal spreaders and aimed at improving distribution, safeguarding the environment, complying with the regulations in force and reducing the costs of fertilizing.

Over the long term, it is anticipated that there will be a wider adoption of slow acting nitrogen fertilizers, to be used almost exclusively at the time of seeding, coupled with considerable restrictions or even prohibitions on the use centrifugal spreaders (due to their associated environmental problems) and a consequent new interest in pneumatic spreaders (mainly for use with incorporated phosphate and potassium fertilizers). New types of spreaders will also be developed for use with seed drills, designed to provide: sufficient operating range, real-time control and adjustment of the application rate, and determination of the machine's position in the field.

4. Conclusions

The considerable present-day wastage of mineral fertilizer will no longer be acceptable in the future, due to the economic and environmental penalties.

In addition to identifying appropriate design solutions to this problem, it is necessary to educate the operators about the factors which affect mineral fertilizer distribution, through the provision of more specialised training. This will have to be accompanied by the mandatory certification of the functionality and safety of new spreaders, and by a periodic functional inspection and adjustment of the machines already in use. To facilitate the latter task, the chemical industry should also specify the principal characteristics of each fertilizer (grain size, rest angle, specific weight) on its packaging, or at least periodically provide this data to the spreader manufacturers, so that they can update the adjustment tables provided with each model of spreader. This need is particularly strongly felt due to the increasing number of fertilizer manufacturers on the international marketplace, which makes it difficult for the operator to identify the necessary data for correctly adjusting the spreader, and also due to the increasing use of electronic systems and components which require periodic functionality checks.

It would also be useful to reduce the gap between the various national regulations (at least within the European Union) in this regard, so as to avoid creating "artificial" differences between the production costs in different countries. In this connection, it will also be necessary to review the limits and methods for evaluating the uniformity of transverse distribution. The recourse to the Coefficient of Variation (CV), as well as other relative variability indices, does not in fact take into account the spatial distribution pattern of the data. This means that the same value of CV can be associated with distribution patterns that differ considerably in shape (**Fig. 18**). In the absence of specific experimental results, it is at present difficult to determine which distribution pattern provides is most advantageous for crop yields. It is therefore to be hoped that the necessary experimental work will be completed, making it possible to define a more appropriate statistical parameter, that is better able to also take the spatial dispersion of the data into account.

From the purely technological standpoint, and with a view to the development of precision agriculture, it will be necessary to develop actuators with very low response times (1-2 seconds) so as to avoid imprecision in the application rate at the high forward speeds often used for mineral fertilizer distribution (up to 17-20 km/h), to harmonise the different systems of communication between the actuators and control units, including the corresponding software, and to draft standardised regulations for the certification of their performance.

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Fig. 1 - Uniformity of transverse distribution (as C.V.) observed in a study conducted by DEIAFA, University of Turin, on over 20 spreaders

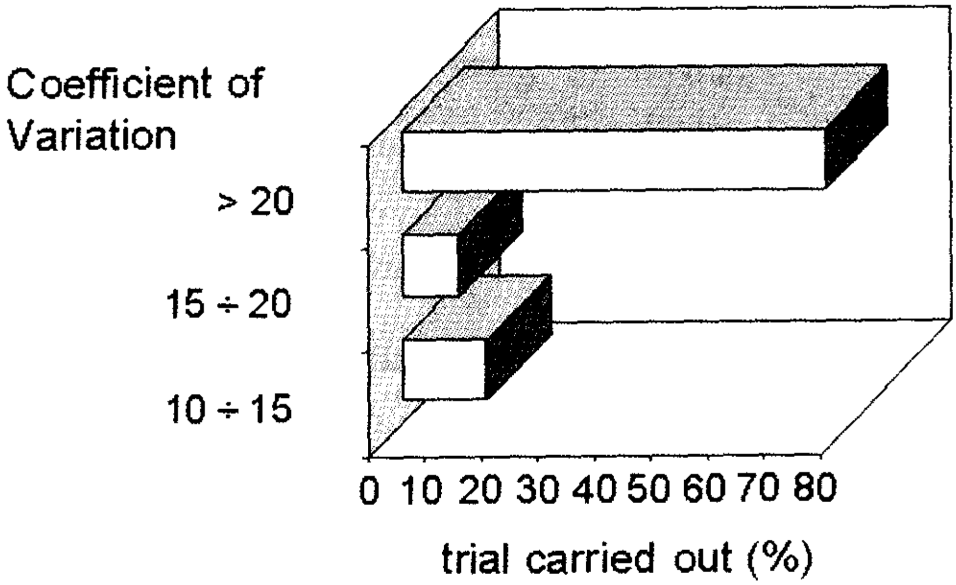

Fig. 2 - Difference between target application rate and effective application rate observed in a study conduct-ed by DEIAFA, University of Turin

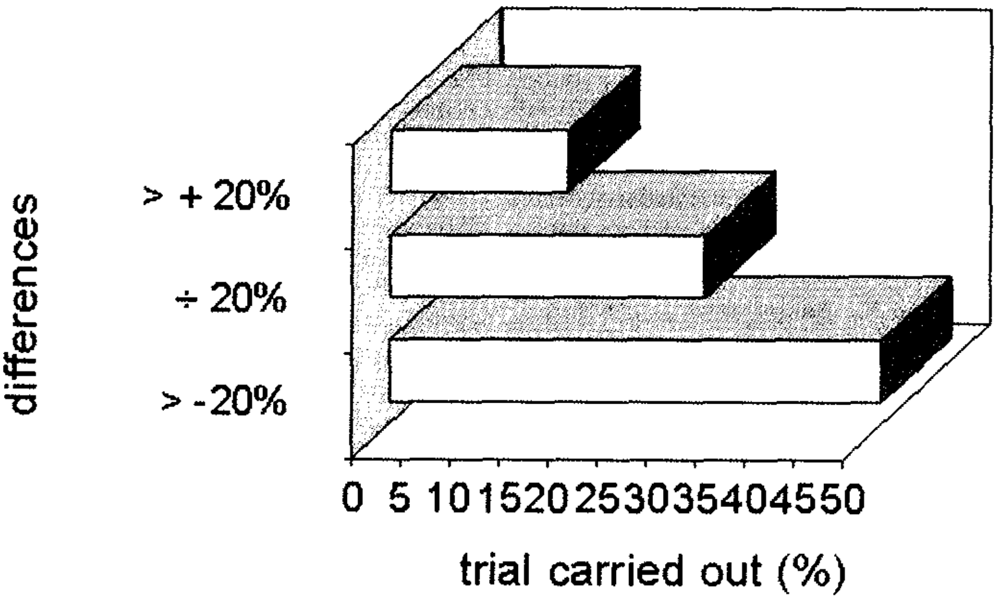

Fig. 3 - Main parameters affecting the development of new technologies

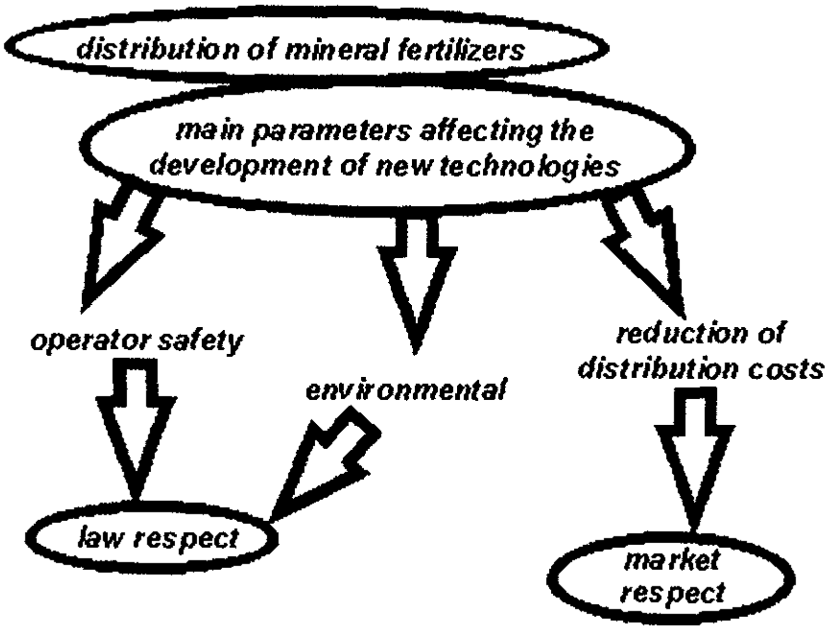

Fig. 4 - Example of yield response to variations in fertilization. On the nearly straight stretch, plus or minus (deficiency - excess) variations of equal magnitude in the fertilizer application rate produced a greater difference in yield (DP) in the case of under-fertilization (DPd greater than DPe). On the curved stretch, corresponding to the maximum recommended fertilizer application rate, the difference in yield response between the two fertilization levels (deficiency and excess) was of equal magnitude

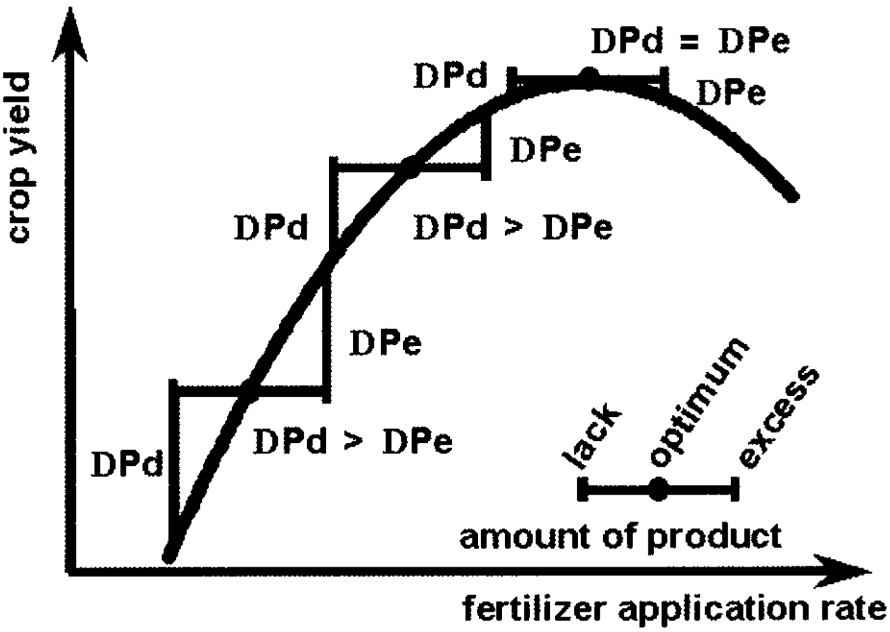

Fig. 5 - Hydraulically actuated disc

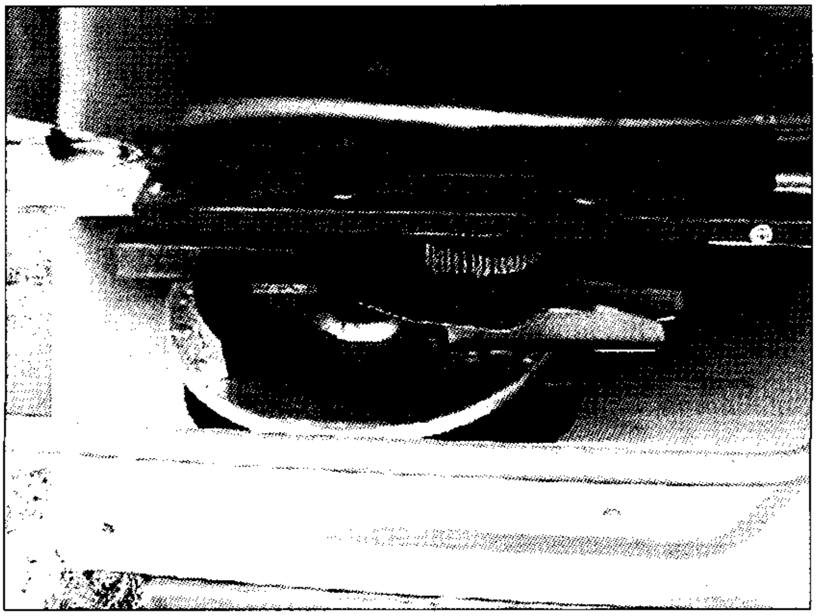

Fig. 6 - Electronically metered fertilizer flow from the hopper to the distribution spinner

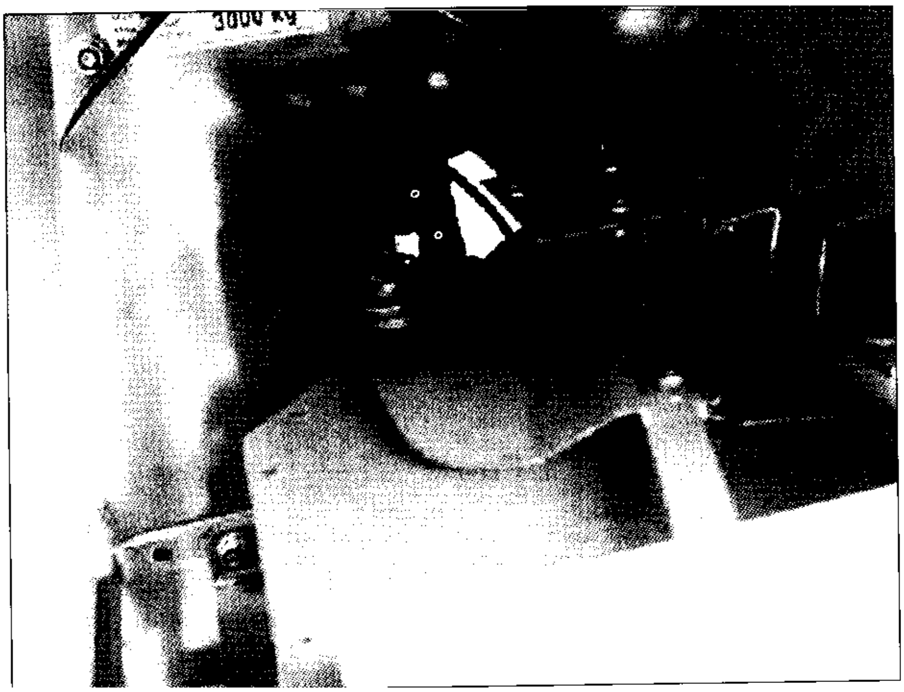

Fig. 7 - Example of distribution spinner with blades of different shapes and lengths, which position relative to the spinner itself can he modified

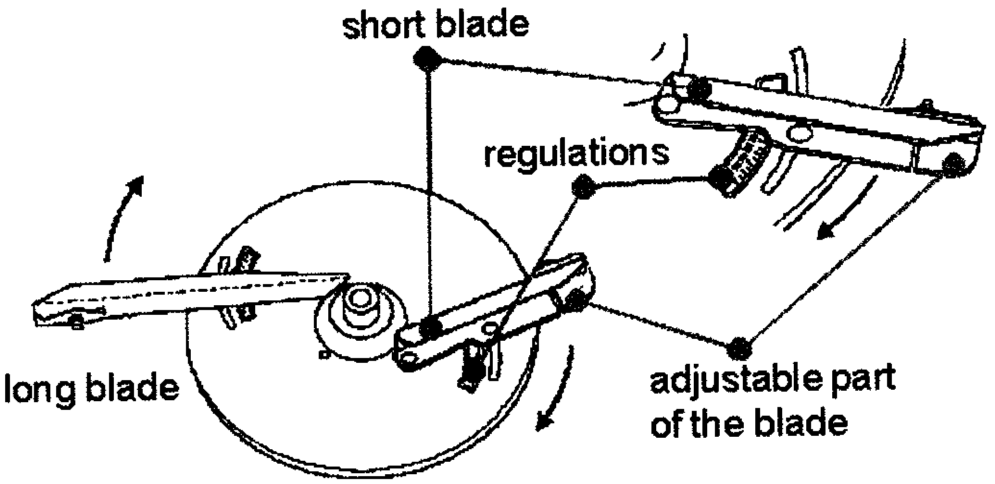

Fig. 8 - Possibility of varying the drop point of the fertilizer on the spinner by altering the position of the latter relative to the hopper

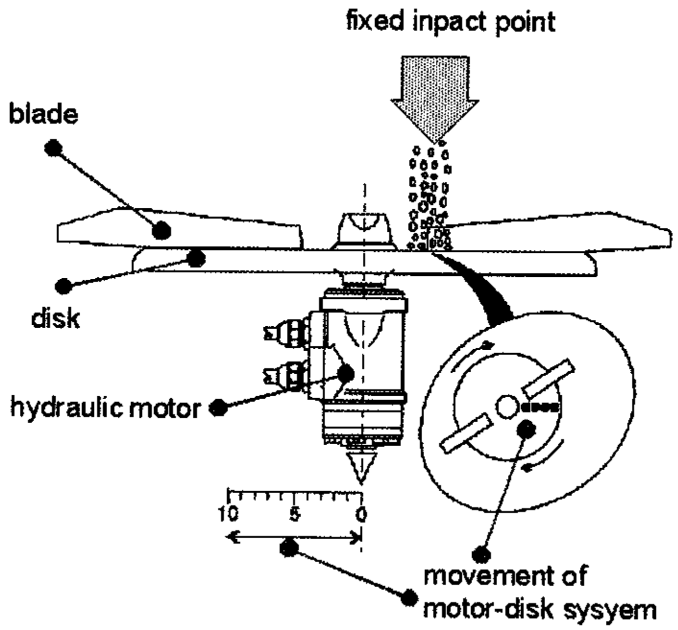

Fig. 9 - Examples of distribution on the field borders with pneumatic and centrifugal spreaders

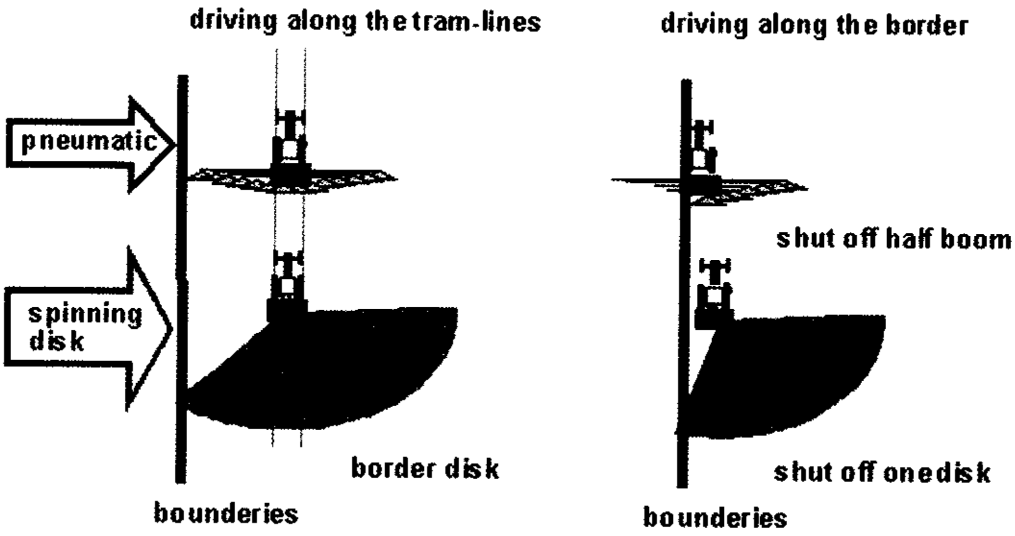

Fig. 10 - Distribution on the field borders from the tramline with a centrifugal spreader. Only the innermost spinner is used, which is fitted with a special screen

Fig. 11 - Example of screening of the spinner for distribution on the field borders, with automatic-operation of the screen

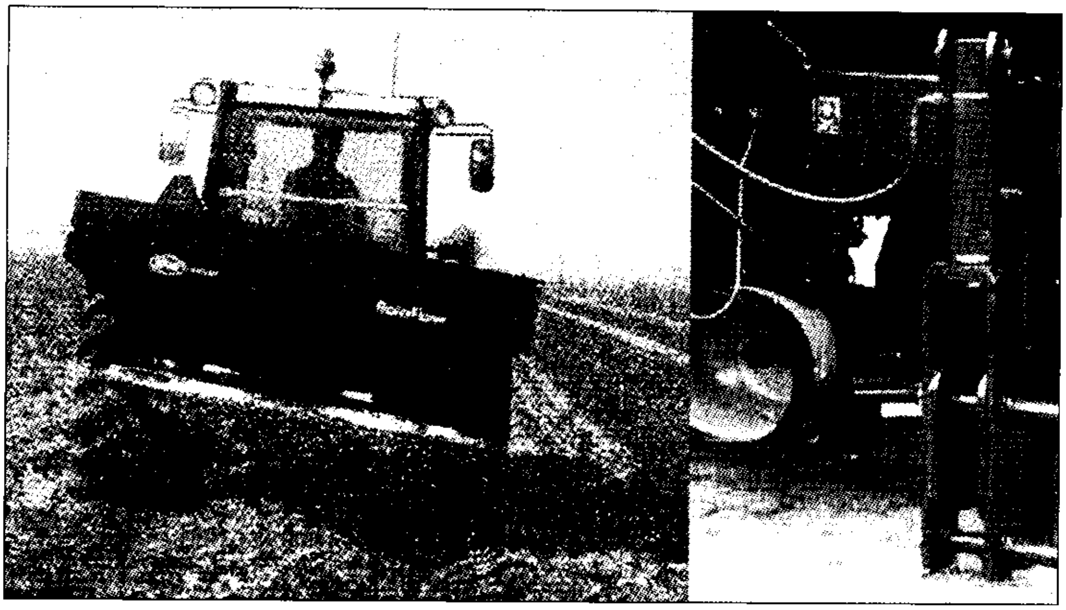

Fig.12 - For correct application of the fertilizer near the field borders, it is possible to automatically vary the height of the spreader relative to the ground

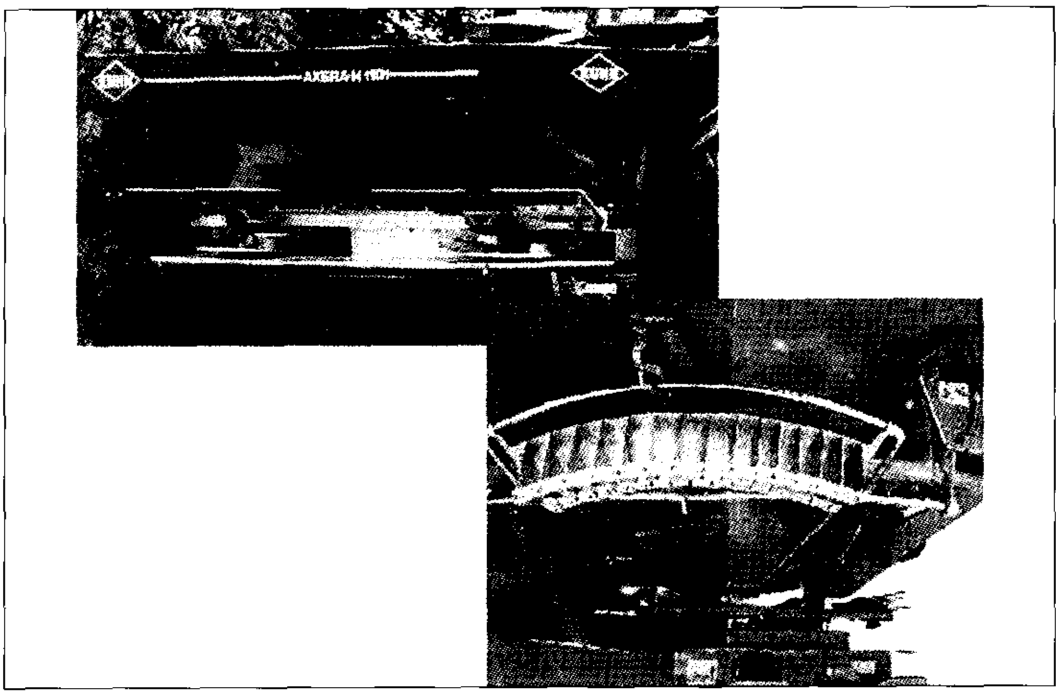

Fig. 13 - Unit for controlling the application rate which supplies the operator with real time data on the application rate, the fertilized surface and the ground speed

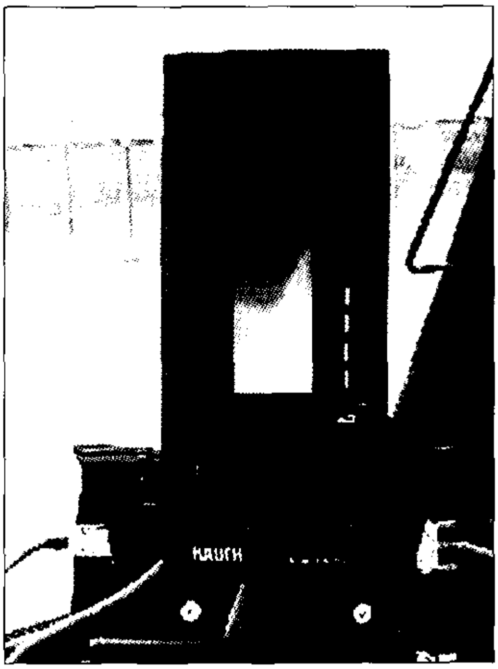

Fig. 14- Components for differentiated fertilization with mapping system

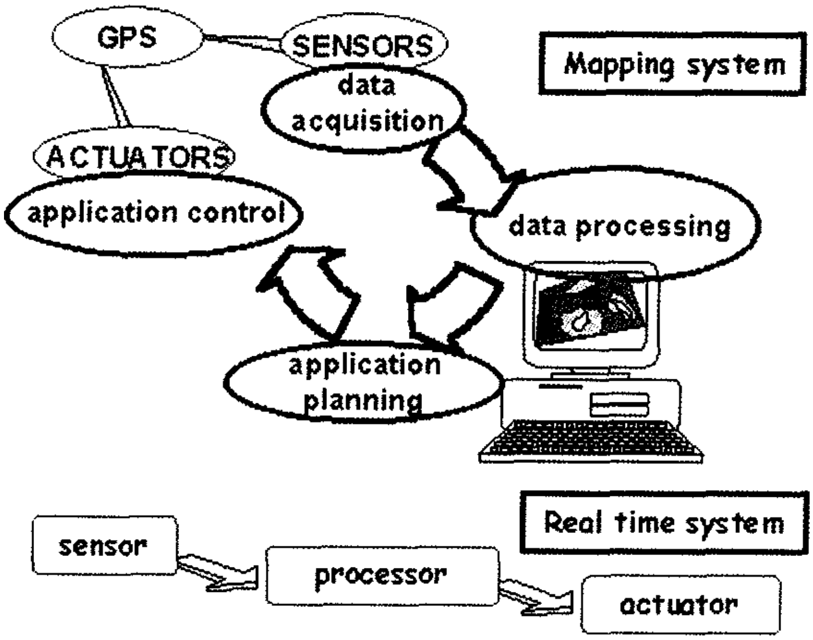

Fig. 15 - Example of real time sensing and application

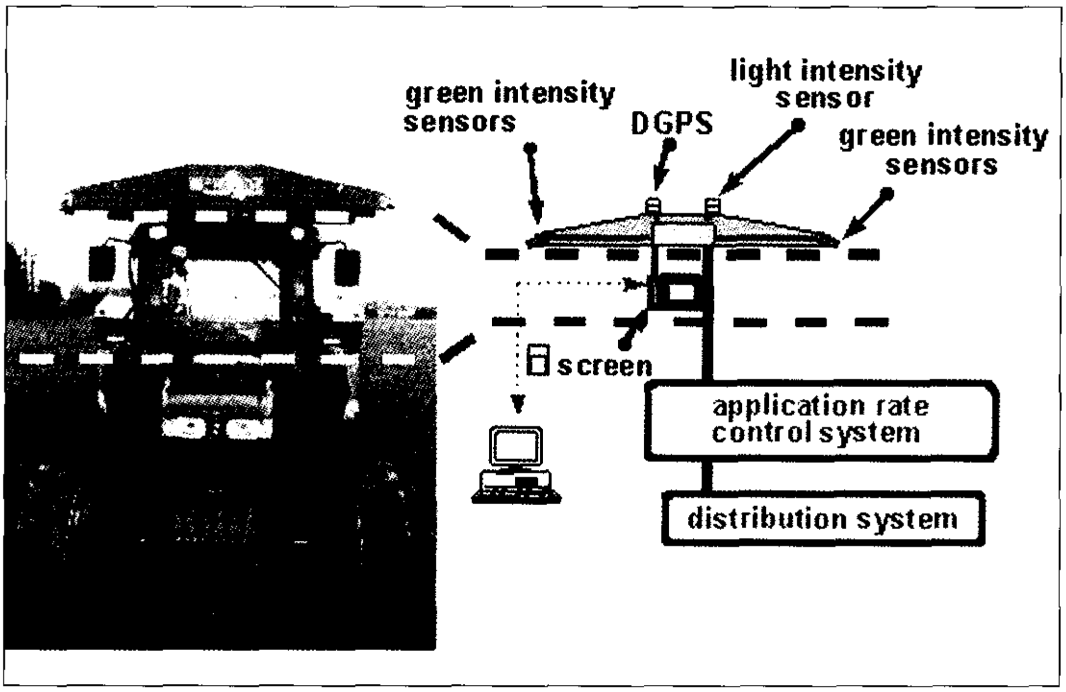

Fig. 16-Annual nitrogen consumption in Europe

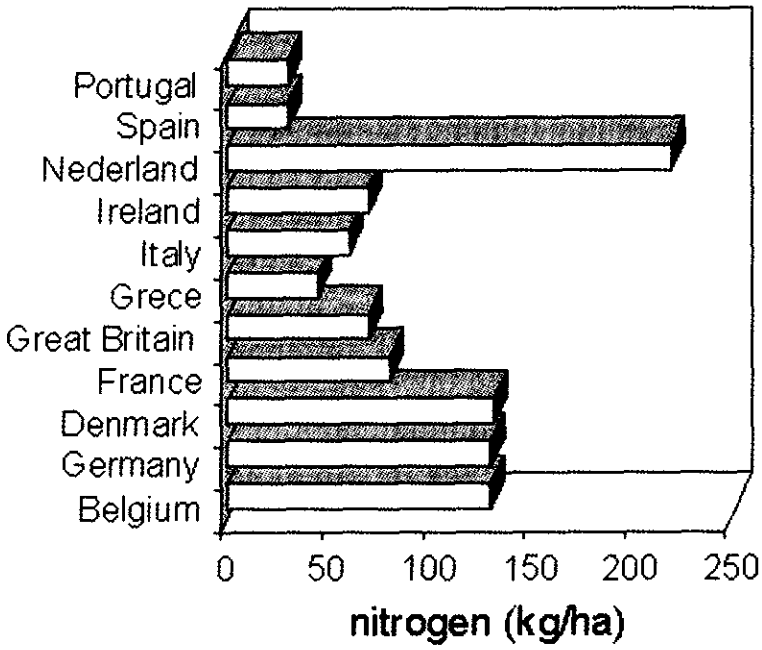

Fig. 17 - Wheat yields obtained following fertilization with ammonium nitrate with and without a nitrification inhibitor (source BASF)

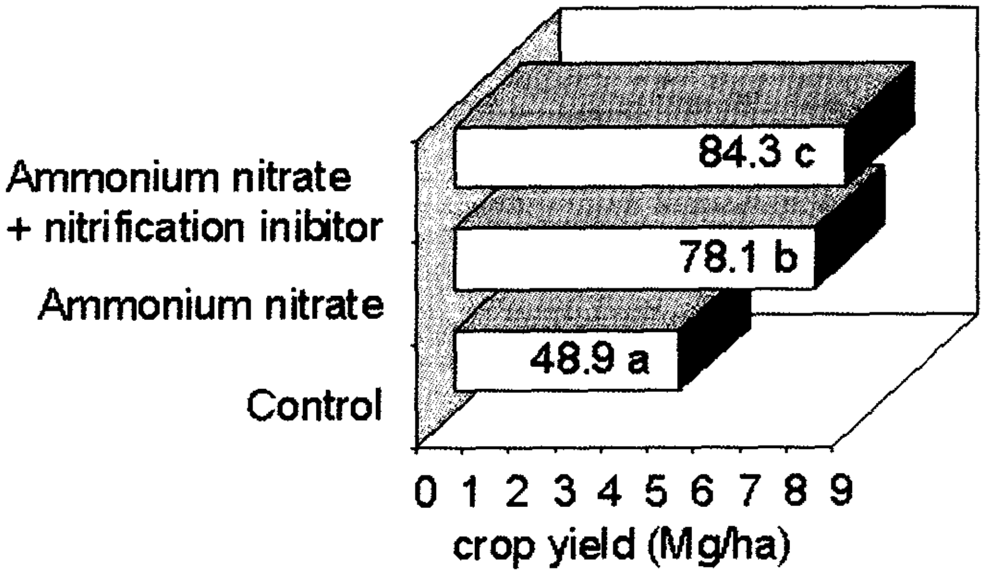

Fig. 18 - Example of transverse distribution patterns all characterised by the Same C. V. (15%)

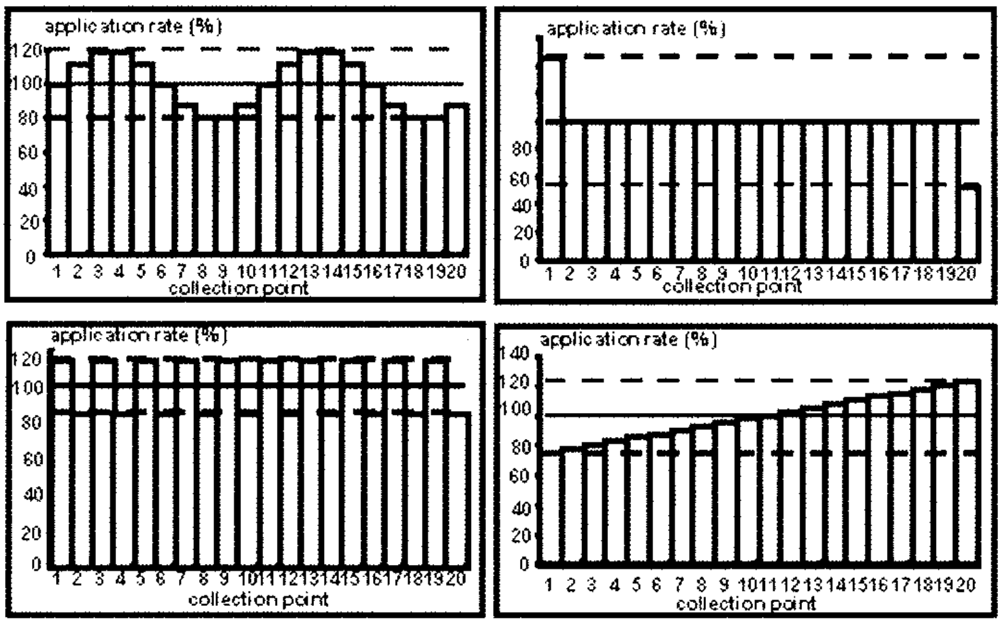

Table 1 - Structural modifications of slurry tankers necessary for assuring operator safety

TYPE OF MODIFICATION	HAZARD	REGULATION
Development of a hopper of suitable shape and size	Fatigue or injury during loading operations	EEC 89/391/654/655/656 – 90/269/270/394 /679
Development of systems for supporting the machine when isolated	Crushing	pr EN 1553-1 pr EN UNI 144044 EEC 89/392 – 91/368 – 93/44/68
Fitting the hopper with a fixed metal grille or other type of guard for protecting the mixer	Entanglement in rotating parts	EEC 89/392 – 91/368 – 93/44/68
Addition of guards to prevent accidental contact with the distribution system	Contact with moving parts of distribution system	pr EN UNI 144044

DISCUSSION

Hugo CETRANGOLO

Argentina

You talk of the high technology of the machines, but I think that the software technology and the organisation of distribution are very important too. In recent years we have seen that many fertiliser industries have also followed distribution, recommending the use of better, bigger and more modern machinery than the farmer can have. Do you think there is a different approach towards the distribution carried out by the farmer and that by industry?

Paolo BALSARI

That's a difficult one to answer because you have touched upon an important topic in terms of the reduction of distribution costs. Industrialised countries used very big bags with a capacity of 500 kg. In my opinion if the contractor is able to find and storage the fertiliser himself, he will reduce his costs. I mean if I'm an ordinary farmer and I buy one thousand tonnes of nitrogen I will pay a certain amount of money, but if I buy 10 or 100 or 1000 thousand tonnes I will pay a different and lower unitary price. Being able to offer the farmer fertiliser and spreader too will be the solution to reducing the distribution costs paid by the contractors.

Ladislav NOZDROVICKY

Slovak Republic

I would like to give you a little information on the fertilising problem in our agriculture. After ten years of dramatic political and economic changes, the mineral fertiliser amount was decreased from 250 kg per hectare of arable land to 50 kg. This had a very bad effect on soil fertility and also on the whole fertilising machinery system used by contracting companies. Now after the decrease in the amount of fertiliser we are looking for better systems to replace the obsolete machinery. At our department, based on the experience in the Czech Republic, we have compared two systems. The first is a track mounted on a rotary spreader, while the second system is a special applicator manufactured by an American company, with a very high capacity. This very big applicator allows for a reduction in costs while offering the best results at the same time.

Pierre ABEELS

Belgium

With regard to question of machine autonomy, farmers would like to have more autonomy with bigger tanks. For that reason they are trying to limit temporary storage close to the field, because they are running from large storage facilities to the field each time. The solution will be to have big tanks in different positions, or locations, to increase the load and decrease the traffic. Another point is the loading problem, particularly the flouting of standardisation loading limit for the equipment. What do you think of these two issues and what is the situation in your country?

Paolo BALSARI

I agree with you as far as machine autonomy is concerned. This is because now there are quite a few self-propelled spreaders. I think that the fertiliser industry can help us by trying to increase the amount of nutrient elements in the fertiliser. I feel that in future it will be not convenient to use complex fertilisers with a very low total amount of elements; we have to look at fertilisers with a higher content of elements. This may ease the problem of machine autonomy a little. Also a storage system located closed to the field might be a good idea. As regards loading, we tried to increase the loading spreaders be means of compromises. If you remember in my first figure I showed the nutrient amount per hectare *in the world in the last 10 -15 years: the decrease you saw has continued. This is why I can't understand why in Europe we are far too far behind the United States. Probably it will decrease, as will the loading problem, less fertiliser per hectare can be applied.*

Antoniotto GUIDOBONO CAVALCHINI

Italy

I think that actually in the agricultural integration process the fertiliser industries will offer the product and service, too: i.e. the product spread directly in the field. In this situation the constraints will change completely, because industry will use large, specialised machinery. I have just heard a very interesting in-depth speech by Prof. Balsari, who gives us a clear picture of what should be done with current fertiliser spreaders. In Europe in particular we should take into account that the European agricultural trends are moving towards biological and organic agriculture aspects, and this will completely change fertiliser types. We have to think about this idea which, at the moment, involves a small percentage of European agriculture. In the future we will have a completely different kind of agriculture, so we should start studying the new problems straightaway. Let me now add some main guidelines comments and to offer you a proposal for the next years. I would like to spend some words about a new field, I think is rising in agriculture, in which we should investigate, or, at least, put our attention. The field concerns the reuse in agriculture of some civil and industrial effluents. In the mid 19th century, Justus von Liebig founded agroindustry, forecasting its future importance and anticipating the necessity of recycling all residues and waste. Though Liebig's first prediction has long been a reality, the second still remains an ideal. Also a reality today are the environmental imbalances caused by the failure to implement recycling. In the past, before the industrial revolution, agriculture interacted with all other human activities, in that everything which was used came from the soil, and was returned to the soil after its use. In contrast, our modern productive-economic system has made intensiveness an essential and intrinsic feature - and even an objective, from a particularly blinkered standpoint. But at the same time, with the contamination of effluents, it has impeded the return of waste to the soil and hence the closure of the cycle prescribed by Liebig, giving rise to environmental imbalances. Such shortsighted conduct may be understandable in the context of industrial activities, whose managers may come from diverse backgrounds and have little or no environmental awareness. But what is totally incomprehensible - other than for reasons of the most obtuse financial expediency - is the failure to even partially close the cycle within the sphere of purely agricultural activities, particularly livestock farming, when they are causing equally serious environmental problems. The question of how to, correctly and in general efficiently, close these productive cycles has already been addressed by Sangiorgi and Rhode. Here, however, I would like to address the problem of closing the cycle within the context of domestic and industrial activities, and in particular the agroindustrial sphere. The reasons why it is important to "close the cycle" are clear and pressing. However, the road to achieving the result is a complex and hazardous one: we refer, to use more familiar term, to the correct reuse and disposal in agriculture of the effluents produced by other sectors, for the general benefit of the community as a whole.The issue is certainly topical and, in this connection, the Georgofili Academy recently hosted an interesting one-day seminar entitled "Agriculture - filter of the waters", devoted to the agronomic reuse of water from civil and industrial sources. The Italian legislators, too, have taken the issue into consideration, with the enactment of a law for promoting the agronomic reuse of effluents. Moreover, Italy is seeing the emergence of a new sector devoted specifically to the distribution of these effluents in the field, which the agricultural contractors are moving into. These contractors handle the distribution of effluents on farm fields, either by surface spreading or subsurface injection, in some cases making use of specific, suitably equipped machines (Terragator). However the role of these contractors remains that of a passive *provider of services, while the management of what should be considered part of a supply chain, taking a systemic approach, is left to third parties contracted by the effluent producing industries to handle the disposal of the waste. The role of the farmer, finally, is even more passive: he merely makes available his land, in some cases receiving, but in other cases also paying out a remuneration.In point of fact, it is interesting to note that the fertilizers approved by the rules and standards for "biological" agriculture are nothing more than industrial effluents, which after a few treatments and bureaucratic procedures are placed, at unduly high prices, in this new agricultural market that is particularly naive and unprepared. Suffice to say that the cost per unit N is approximately 5 times greater than that in mineral fertilizers.In view of the above considerations, the agricultural system needs to take stock of the situation, in order to define its own role and establish a set of rules. These rules must be drawn up within the context of a systemic or supply-chain approach, meaning the supply chain that starts from the effluent - or rather from the process which produces it -and accompanies the waste through the various phases leading up to its agronomic exploitation and distribution in the field. In this connection, we must establish the meaning of agronomic reuse and disposal, determining whether to give greater weight to one definition or the other. In my view, in the current productive economic context of an industrialised country such as Italy, the appropriate term is "disposal". Clearly, and especially if the philosophical basis is the ecological concept of closing the cycle, this disposal is inseparable from agronomic reuse, and hence from correct agronomic practices which determine the timing and methods for disposal.From this perspective, it is the agricultural system which permits the re-dilution of what others have concentrated to create pollution, thereby providing a service first and foremost to the effluent producers and, in the final analysis, to the community as a whole, for which it must in some way remunerated. After all, the concept of agriculture as not just a primary but also a services system is now well accepted by the current public opinion. The question, now, is to extend the range of services provided. If, on the other hand, we prefer the designation "reuse, or agronomic exploitation", the tables are turned and agriculture becomes the user and client of the effluents, for which it must therefore pay the price set by the industry, as in the above-mentioned case of fertilizers for biological farming. However, remunerating the service entrains a certain risk that farmers will only be willing to perform the disposal associated with agronomic exploitation, if the payment for that service is considered sufficient.It is thus important to carefully define the entire process, studying and identifying the most effective technologies and methods, as well as implementing appropriate measures and mechanisms for controlling and monitoring the supply chain. An initial approach will most likely rely, with regard to distribution, on the slurry spreading technologies described by Sangiorgi, and with regard to monitoring on a combination of memory cards and geopositioning systems (GPS), for a result that is similar to, but more sophisticated than, the tachographs used on commercial trucks. Nonetheless there still remains broad space for agricultural engineering research. Only after achieving adequate levels of efficiency, and conformity to agronomic and ecological requirements, with a system of controls that ensures against fraud, can we speak in terms of a service provided by agriculture, and in consequence remunerate the primary-services system. Hence the proposal that, in a forthcoming year, we address this broad-ranging issue and define the applicable technologies for both the emerging and industrialised countries.*

Paolo BALSARI

I completely agree: in the future we will be looking at organic farming mechanisation, because it will be developed a lot. Of course, we will not be able to use more chemical fertilisers with it, but this will not resolve the loading problem. If you take into account that 100 kg of pig slurry contains only 1 kg of nitrogen while 100 kg of urea contains 46 kg nitrogen, you can strike a balance, but in one go you have to introduce 46 times more raw *product. It dramatically increases your loading problem. I suggest that fertiliser manufacturers increase the nutrient amounts inside the fertilisers. As for organic distribution we can only increase or reduce the distribution flow.*

John SCHUELLER

My comment is on precision agriculture which you discussed earlier, because I think you talked about a very old coefficient. A recent study in Brazil showed that under the trees the soil was very acidic and between the trees it was very basic. What they discovered was that when they were spreading lime, the particles would not fly very far and soil was getting basic between the roots. If we want to have precision agriculture we first have to get control on spreaders and applicators. My second comment relates to the figure of the old farmer. Those of us in the developed countries will remember grandfathers: they knew quite well where they need to apply more fertiliser and when they did not. Now people providing equipment for the smaller or less developed farmer should help practice precision agriculture, making the equipment readily available from the tractor seat. With this the rate of fertiliser application can be varied by the farmer himself, who can achieve very low costs for precision agriculture. Nevertheless this happens only to the men that have been educated and trained, as you pointed out before.

Giuseppe PELLIZZI

A short comment from a general point of view. The problems concerning the distribution of manure, slurry and mineral fertilisers are becoming more and more complicated. To solve them we have to consider the whole system, not just the machine. This is an approach we have to take into consideration for all the fields of the future of mechanisation.

Jaime ORTIZ CAÑAVATE

The idea of Prof. Balsari that in the future it will be unprofitable to use a spinner for fertilisers seems to me rather too drastic. I think it would be possible to use the spinning disc fertilisers in that the rotation of their two spinners can be adjusted. Also, I recently saw a machine that measures the rate of fertiliser application by the pressure difference on the inlet and outlet of the hydraulic motor.

Paolo BALSARI

I agree with you, I want to be drastic to have wider discussion about this topic. Why is it that on the subject of precision farming none of the manufacturers has understood that it is easier to control the flow rate with a pneumatic spreader? Why does everyone move to the spinning disc? Because, probably, the contractors want to have a very wide working width. Mentioning that the spinning disc spreader will be not used in the future was just a way of introducing the alternative of the pneumatic system. We have to try to push this one, finding a solution able to make it useful for the contractors too, or maybe force them not to work with such a high working width and keep them to 44 m, the current maximum.

Lothar FISCHER

Germany

Changing mentality, said Prof. Pellizzi, is very important. If you look back at what we have done in industry in the last 10 years, we have to learn that: we cannot increase output, just speed up the process. In addition we have to understand that it is important to involve our workers, making them more responsible. We have a lot of things: speed in factories, quality, acceptance. By switching this experience to the customers and to the farmers we can give better service when we sell tractors *or spreaders, thus making the customer more aware of what the products capacities are. If we can involve university institutes, manufacturers and customers in understanding what is the best for nature and income, we will obtain a different product which can be used to better effect.*

Karl Th. RENIUS
I would like to support that comment from the university side, as well as from the practical farming side, because it may be interesting for the peak loads and the load of tractors implements. In Germany we have created a system to give advice to people who are buying implements, such as on matching the implements to the tractor, comparing the total load amount they can put on to prevent un-balanced tractors causing accidents. I think that today the peak load is very high, about 78% sometimes 90% of the net weight of the tractor. For this reason achieving good working quality and a low potential level of accidents will become more and more important.

Oleg S. MARCHENKO
Russia
We have information on the influence of the different mineral fertilisation rates on crops, but no-one has spoken of the quantity of fertiliser lost? There is valuable information on the washing-out level to the deep horizons of mine-rally fertilised soil. This depends on the different application rates and on the constancy of fertiliser distribution. It would be interesting to have some information on this from the speakers.

Paolo BALSARI
I can say something about run-off It is closely related to the type of application; trying to in-corporate the fertiliser, I reduce the run-off as happens with manure. When I don't do that, when I increase the application rate I in-crease the run-off it depends on the soil and the application type. When I mentioned environmental losses I put all these elements together. For example, when we apply urea without incorporating it into the soil, we loose from 10% to 40% of ammonia in the atmosphere, causing big losses.

Francis SEVILA
I have one short comment on the management of complexity mentioned by Prof. Pellizzi. We find in the topic of, fertiliser application an excellent example of how to co-operate with this complexity. All the subjects discussed by the Club of Bologna are fighting against complexity. Maybe the way to solve this situation would be to cooperate with the subject you put on the program, not only from a mono-disciplinary, but from a multi-disciplinary point of view. Maybe we should to do a better job in helping industry and the different countries around this table to under-stand what machinery means for the rest of the disciplines. We may ask our speakers to have a different approach on the subject and try to discuss the machines under various disciplinary aspects, instead of describing state-of-the-art industry or research.

Jorge A. HILBERT
Argentina
We spoke about how to implement the system of controlling working machinery on farms. I would like to know if there are any experiences on that subject here in Europe and what the main results are.

Paolo BALSARI
There is in the Netherlands an association called OMS and formed by fertiliser manufacturers and by contractors. They contact the farmers to sell fertiliser and, at the same time, they test the spreaders. This is the only in-stance I know of. In Italy, with CONAMA, it was also proposed to make an inspection on each type of spreader in order to check their performance and, more importantly, to develop an information system for farmers on how to use the spreaders correctly.

Advancements on the technologies for inputs distribution: the case of irrigation

by ***Elisha Kenig***
Israel

1. Introduction

With Pressurised Irrigation Methods (PIM), water is simultaneously spread over an entire farm field surface, with a highly uniform distribution pattern. The ability to provide the exact dose of water required by the crop, even if it is a small one, is the most important advantage of PIM. High water utilisation efficiencies, in the range of 75% to 95% (depending on the method), can be achieved with PIM. In open irrigation, the water spreads over the irrigated area by the effect of gravity. Full coverage is only obtained after a certain period of time has elapsed, and a certain amount of water has been distributed. The minimum irrigation rate required to cover the area may exceed the crop requirement at a particular time. The uniformity achievable with open irrigation is significantly lower than that of PIM - only 50% [4], [5]

PIM can be divided to three main types of systems: drippers, micro-jet\sprinkler and sprinklers. Each of these systems is characterised by the specific flow rate and operating pressure range of the nozzle:

- dripper, flow rate range: 1 l/h to 8 l/h, at 10 m pressure;
- micro-jet\sprinkler, flow rate range: 20 l/h to 160 l/h, at 20 m pressure;
- sprinkler, flow rate range: 250 l/h to 50 m^3/h, with operating pressure range: 25 m to 50 m.

The first two methods belong to micro-irrigation family. Their goal is the wetting of the crop root system and the field as a whole (less than 100% coverage). Dripper systems are suitable for row crops (vegetables and field crops) and orchards. Micro-jet sprinkler are suitable for use under the tree canopy in orchards. The goal of the sprinkler method is to wet the entire field (100% coverage), imitating the effect of rain. In order to achieve a uniform wetting pattern, an overlap between adjacent sprinklers is necessary. The sprinkler method is suitable for field crops.

The pressurised irrigation methods known to date were introduced into commercial use during the course of the 20^{th} century: sprinklers in the third decade, drippers in the sixth decade and micro sprinklers during the seventies. Since then, they have undergone a number of developments which will be discussed in this paper.

2. Dripper

The dripper is an irrigation nozzle which emits water at a low flow rate. The dripper is attached to a pipe, or dripline, which contains water under pressure. As the water moves along the flow track of the dripper it gradually loses pressure and trickles out in the form of droplets. These drops create a moistened volume in the soil. Already in the early sixties, this method was found to provide the root system with good conditions of water, air and nutrients. As a result, water and fertilizer utilisation efficiencies could be increased. Because the irrigation takes place directly on the ground, salt water can be used effectively. The low flow rate of the dripper is achieved through the use of relatively small water passages, making these systems susceptible to clogging [1].

The advantages of the method disappear if clogging occurs. The resulting gradual decrease in the dripper flow rate is also detrimental to water utilisation efficiency. Ever since the sixties, drippers and driplines have undergone a process of continuing development primarily aimed at making the dripper less sensitive to clogging!

Nowadays, the use of water recycled from effluents is an environmental necessity. How ever, such recycled water contains a considerable solid fraction. The drip irrigation method is the most secure system for using recycled water. The new models of dripper which are produced today are able to function with recycled water.

Up until a few years ago, the lowest dripper flow rate was 2 l/h. Subsequently, changes were made to the dripper flow track, and today we have 1 l/h drippers with water passage dimensions to the 2 l/h drippers of yesterday.

What's more, today we also have minute drippers with very restricted range of flow rates, from 0.15 to 0.3 l/h, and these are suitable for use in soil-less media cultures.

Drippers can be characterised as a function of three main parameters: type of dripper, dripline and quality of production.

2.1. Drippers types

2.1.1. In-line dripper

This type of dripper has a long flow track, with tooth connectors in either side. It is connected to polyethylene pipe sections to create a lateral. Most of the water runs through the dripper centre and into the following drippers. The popularity of this system declined with the advent of the integral dripline. With regard to the flow track, it was initially of the screw type with a cross section of less than 1 mm. Subsequently, the labyrinth flow track was developed, with cross sectional dimensions close to 1 mm and even higher.

2.1.2. On-line dripper

The on-line dripper is connected to the lateral by means of a barb. Non-regulated, regulated and regulated non-leakage (new development) types exist. Through the use of a splitter, it is possible to obtain a multi outlet dripper.

This type of dripper initially had a nozzle - short flow track construction. In order to achieve the requisite flow rate, the nozzle diameter was around 0.5 mm. This had two drawbacks: sensitivity to clogging, and inaccurate production.

Today, on-line drippers have a long flow track labyrinth construction.

2.1.3. Integral drip line, lateral with regular wall thickness

This type of dripper is enclosed and welded to the inside wall of the tubing in the manufacturing process. Regular wall thicknesses range from 1 to 1.2 mm. Non-regulated, regulated and regulated non-leakage (new) types exist. There are two different dripper shapes: flat or cylindrical. Integral drippers have a pre-filtration section at the inlet to the flow track. In the newer models which are suitable for use with recycled water, the pre-filtration section is enhanced.

2.1.4. Integral drip line, thin-walled lateral

This type of dripper is also attached to the inside wall of the tubing in the manufacturing process. There are several wall thicknesses - the thinner walls should serve as one season laterals. The wall thickness range is from 0.25 to 0.63 mm. The drippers are non-regulated, with a flat or cylindrical shape. The aim of this product is to reduce the cost of the system and increase the variety of conditions in which the dripper can be used.

2.1.5. Minute dripper

The minute dripper has a very low flow rates, in the range between 0.15 and 0.3 l/h. This new development is very suitable for use in soil-less media cultures, where complete wetting of the limited media can be achieved without reaching saturation at any time. Minute dripper flow rates can be achieved in one of two ways. With a pulsator-based split dripper, or through the intermittent operation of a non-leakage dripper.

2.1.5.1. *Pulsator based split dripper*

The pulsator is a device which operates like a heart pump (silicon sleeve diaphragm) and intermittently releases a very small volume of water with a rapid rhythm, through secondary drippers. The pulsator is connected to the lat eral via a filling dripper and releases the water through up to 20 outlets. A simple dripper cannot be split to more than 8 outlets. The 2 l/h filling flow rate divided by 20 gives an output flow rate of 0.2 l/h for each secondary dripper.

2.1.5.2. *Intermittent operation of non-leakage dripper*

When non-leakage drippers are operated intermittently for short periods (seconds) within brief intervals (minutes), the result is a minute flow rate as an average on the time base. A dripper with a 2 l/h flow rate, if operated for 60 seconds every 10 minutes, will result in an average rate of 0.2 l/h.

2.2. The dripper flow track

The three most important factors characterising modern drippers are:

- the quality of the flow track;
- the shape of the dripper;
- the operational characteristic

2.2.1. The quality of the flow track

The flow track of modern drippers designed to operate with low quality water consist of two sections.

The 1st is a pre-filtration section, and the 2nd is the flow track itself.

2.2.1.1. *The pre-filtration section*

The function of the pre-filtration section is to protect the flow track from clogging. The particles which succeed in passing through the pre-filtration section should be able to pass all the way through the flow track. Drippers which are designed to operate with recycled water have an extensive pre-filtration section.

2.2.1.2. *The flow track*

Modern dripper flow track can be described in terms of four parameters:

- the cross sectional dimensions – the depth and width should be as large as possible;
- the length – it should be as short as possible;
- the shape – angles, rounded edges and the like might increase the likelihood of obstruction (it is very difficult to relate);
- the flow characteristic – it should be as turbulent as possible. The degree of turbulence depends on a combination of the above mentioned factors. If higher turbulence is achieved, the flow track can be bigger and shorter. The flow characteristic thus influences the operational characteristic.

2.2.2. The shape of the dripper

There are two possible dripper shapes: flat with 1 outlet hole, or cylindrical with more than one outside hole. If there are two outlet holes, one of them faces upward. When irrigation is completed and the lateral starts to drain, the upper hole will let air into the lateral, thereby preventing soil particles from being sucked into the dripline and clogging it from the outside.

2.2.3. The operational characteristic

The operational characteristic describes the dripper flow rate as a function of the inlet pressure. It is given by the equation [3]::

$$q = k \cdot p^m$$

Where: q = dripper flow rate (l/h); k = coefficient; p = inlet pressure (kPa); m = dripper exponent

For non-regulated drippers, the value m represents the turbulence level. If m is smaller than 1, the turbulence is stronger. More details are given in the following table:

- m=1: Laminar flow
- m <1: Turbulent flow, for modern drippers: 0.4< m <0.5
- m =0: For regulated drippers in the regulation range

For non-regulated drippers, the exponent determines the maximum lateral length which can be installed on flat area for a given discharge difference. Details for 10% discharge difference are given in the **Table 1**.

From this Table we find that, the smaller the value of m, the longer the lateral can be.

Innovations in non-regulated drippers: today several new drippers are being manufactured which have exponent values of less than 0.5.

Innovations in regulated drippers: a non-leakage mechanism is added to the regulated dripper. Laterals with such drippers are left full of water between successive water applications.

2.3. Dripper production quality

It is not enough to achieve dripper quality in terms of the above mentioned factors. It is also necessary for their production to take place in accordance with quality control precepts, as expressed by international certification standards. There are two sets of relevant standards:

- factory quality control is conducted according to ISO-9000;
- the products are subjected to random sampling and testing by the laboratory of the standards institution and found to conform to the requirements.

There are two International Standards dealing with drip irrigation: ISO-9260 [6] for drippers, and ISO-9261 [7] for dripping lines. One of the most important parameters is the uniformity of distribution.

The present-day standard distinguishes between two categories, A and B, as a function of three tested parameters:

- the variance (*Cv*), is a statistical value that is checked for a sample of 25 drippers;
- the deviation of the average discharge rate for the sample ($\bar{q}$) from the nominal flow rate quoted by manufacturer (q_n);
- the deviation of the "operational characteristic" of the sample from the value quoted by the manufacturer.

2.3.1. The variance – Cv

The variance is the ratio of the standard deviation to the average sample flow rate, expressed in percentage terms.

$$Cv = \frac{S_q}{\bar{q}} \cdot 100$$

where: S_q is the standard deviation

$$Sq = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(Xi - \bar{q})^2}$$

and: $\bar{q}$ is the sample average discharge

$$\bar{q} = \left[\frac{1}{n}\sum_{i=1}^{n} Xi\right]$$

n = number of values in the sample;

Xi = discharge measured values.

A high value of Cv means that the individual sample flow rates are widely scattered around the average value.

2.3.2. Deviation of the average flow rate for the sample ($\bar{q}$), from the nominal flow rate quoted by manufacturer (q_n).

This parameter determines whether the average flow rate of the tested sample differs from the flow rate quoted by the manufacturer. The flow uniformity parameters required by the standard are given in **Table 2**. Category A is more stringent than category B, and therefore category A drippers are of higher quality.

2.4. Dripper summary

Over the past few years, the trend in the development of drippers has been toward making the passages in the flow track wider and shorter. The flow turbulence has also been increased. In fact, these two factors are interdependent. As a result, the aim of reducing the minimum dripper flow rate to 1 l/h has been achieved. The need for very low flow rates has been met by the use of the pulsator as well as by the intermittent operation of non-leakage drippers. The need for reducing costs and extending the range of application of the drip method has achieved with thin-wall integral driplines. And the last important item concerning the drip method is the customer's demand for a high quality product.

3. Micro-jet sprinkler

The micro-jet sprinkler system is mainly used for under-tree orchard irrigation. The device normally has a bridge construction, with the nozzle attached to one side and the spreader to the other. The nozzle and the spreader can be replaced. The spreader can be of the static – jet or dynamic – sprinkler type. The device itself is attached on top of a stand which stabilises it on the ground. Up until a few years ago the minimum flow rate was 40 l/h.

The important developments regarding the micro sprinkler system are the follows:

3.1. Flow rate of 20 l/h

Micro-sprinklers with 20 l/h flow rates are potentially able to compete with drip irrigation for orchards.

Micro-sprinklers are also available as two-stage spreaders. The 1st stage has a range limiter which reduces the wetted diameter for young plants.

3.2. Vortex nozzle

The vortex nozzle imparts a circular movement to the water before it is ejected. Thanks to this principle, the nozzle can be approximately 20% larger for a given flow rate. For example, for 40 l/h the diameter of a normal nozzle is 1.1 mm, while that of the vortex nozzle is 1.3 mm. The vortex nozzle is more suitable for operating with dirty water.

3.3. Micro-sprinkler without a bridge

With a standard micro sprinkler, the bridge hinders water distribution. The version without a bridge is able to achieve full distribution.

3.4. Nozzle with built-in inlet filtration

The micro sprinkler system is almost as susceptible to clogging as the dripper. The incorporation of a pre-filtration section into the nozzle protects the nozzle from clogging. When a certain amount of particles have accumulated, the unit can be simply removed and cleaned.

3.5. Micro-jet with strip spreader

In modern orchard plantations, where the plants are spaced 4.5x2.5 m apart and grow on ridges, the use of the micro-jet strip spreader is very efficient. Only the ridge is wetted, while the space between rows remains dry and free for movement.

4. The sprinkler

The sprinkler irrigation system is the oldest pressurised irrigation method. For many years, the sprinklers were constructed exclusively from metal parts. Only recently we find sprinklers being made from plastic parts. Other developments which have occurred are related to the overlapping of water distribution terms.

4.1. Plastic sprinklers

Plastic sprinklers have several advantages over metal sprinklers:

- the nozzles are connected to the sprinkler with a bayonet coupling that is very easy to disassemble in the field;
- the nozzles are colour-coded and easy to distinguish;

- the plastic sprinkler has a longer life;
- the plastic sprinkler is less expensive.

Plastic sprinklers are more fragile, this is almost their only disadvantage.

4.2. Water distribution uniformity

For many years, water distribution uniformity was measured using the statistical equation [2]. More recently, other parameters describing the quality of distribution have been added. With the advent of computer technology, manufacturers have become able to supply real mapping of the distribution pattern.

4.2.1. Cristiansen Uniformity Coefficient (CUC)

$$CUC = \left[1 - \frac{AD}{AV}\right] \cdot 100$$

Where:CUC = Cristiansen Uniformity Coefficient (%); AD = The Average Deviation (ml); AV = The Average Volume (ml).

When the calculated value of CUC is greater than 84%, the uniformity is considered to be good.

4.2.2. Distribution Uniformity (DU)

$$DU = \frac{ALQV}{AV} \cdot 100$$

Where: DU = Distribution Uniformity (%); $ALQV$ = The Average of the lowest 25% (ml); AV = The Average Volume (ml).

The coefficient DU is the ratio of the average of the lowest 25% of the containers to the general average. The accepted value is 80% or higher.

4.2.3. Scheduling Coefficient (SC)

$$SC = \frac{AV}{AVCDAr\underline{(\%)}} \cdot 100$$

Where: SC = Scheduling Coefficient (%); AV = The Average Volume (ml); $AVCDAr$ (%) = The Average Value at the Critical Area (its size by %).

The coefficient SC expresses the ratio of the general average to the average in the critical area, expressed in % terms. The smaller the critical area, the more restricted the test. The value of SC should be close to 1.

4.2.4. Distribution map

The data presented in the manufacturer's professional catalogues is based on the CUC only. Choosing a sprinkler on the basis of that information may lead to poor performance in the field. In addition to the above mentioned factors, on customer request, the manufacturers can supply full distribution information in the form a map. This information is much more reliable than that which is found in the catalogues.

4.2.5. Distribution uniformity summary

Nowadays, when choosing a sprinkler it is not enough to rely exclusively on the manufacturer catalogues.

In addition to the distribution map, the values for the coefficients should be as follows:

- *CUC*: 84% or higher;
- *DU*: 80% or higher;
- *SC*: as close as possible to 1.

5. Conclusions

The above description of pressurized irrigation nozzles should give us the filling that it is possible to fit the right nozzle to meet crop soil and technical aspect demands.

5.1. Drip irrigation

Unfortunately all drippers are dark from outside, so they look similar to each other. In matter of fact they differ in the drippers inside. Being familiar with the technical factor influencing the dripper performance is very important when a decision about what dripper to choose is taking place. When drippers are new most of them “good”. The question is what will be the drippers performance when they get old? Drip systems should be carefully maintained. A good dripper might keep it performance even the maintenance treatments have not been tightly kept.

There are several consideration aspects to choose the right dripper:

- crop, soil and water consideration:
  - crop spacing and soil type – dripper discharge and spacing;
  - soil-less media and it packaging – dripper discharge and sort of connection to the lateral;
  - water quality – dripper discharge.
- technical consideration:
  - presence of pre-filtration;
  - the flow track cross-section dimensions;
  - the flow track length;
  - the m exponent value;
  - the wall thickness of integral drip line;
  - stamp of approval;
- the system cost.

5.2. Micro-jet/sprinkler

Considerations in choosing the right nozzle:

- trees spacing – coverage diameter;
- soil type and profile – nozzle discharge;
- soil preparations shape (ridges) – nozzle spreader.

5.3. Sprinkler irrigation – Full coverage with overlapping

Many farmers got experience with operating sprinkler systems. Execution of overlapping in the field was mainly based on the statistical CUC information, supplied by the manufacturers. For many years it is known that sometime this kind of information is misleading. Nowadays plastic sprinklers with potential for high uniformity level, as steady stead systems became more popular, especially for vegetables. The uniformity performance can be increased if sprinklers spacing in the field are based upon several uniformity equations as well as on a real distribution map. The use of this information for practical purposes is new.

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Table 1 – *m* value influencing the pressure difference (loss) along a lateral layes on flat to obtain 10% discharge difference, for non-regulated drippers.

EXPONENT *m*	PRESSURE DIFFERENCE (%)	LATERAL INLET PRESSURE (m water)	PRESSURE AT THE LATERAL END (m water)
0.66	16	10	8.4
0.50	20	10	8.0
0.40	25	10	7.5

Table 2 – International standard flow uniformity parameters

CATEGORY	*CV* (%)	DEVIATION OF THE SAMPLE AVERAGE FLOW RATE $\overline{q}$ FROM THE NOMINAL FLOW RATE q_n (%)	DEVIATION OF THE SAMPLE OPERATIONAL CHARACTERISTIC FROM THAT DECLARED BY THE MANUFACTURER (%)
A	5	± 5	± 5
B	10	±10	±10

On farm soil – water - crop management: techniques and practices in Egypt

by *Ali Mahmoud El Hossary*

Egypt

1. Introduction

GEB, the pharaonic God for land and water stated that "Appropriate combination of soil - water - plant is the basic requirement for reaping optimum crop production.

For many thousands of years the Egyptians have paid great attention for their water and land, and kept their gaze fixed on their soul source of water "The Mighty River Nile" where they developed their banks, installed means for gauging the River's levels, made use of reservoirs in depressions, built dams and dug canals.

Starting from the 19th century, every attempt was made to control the River's flow while maintaining the required level needed to irrigate the Nile delta and valley. The early 1930s witnessed the building of the Delta Barrages, NagaHammadi and Edfina Barrages. Then Aswan High-Dam was built as a part of a multi-purpose project to protect and control the Nile flow at Aswan.

The High - Dam secures 55.5 billion cubic meters of water per year and no water is being released to the Mediterranean, and droughts are no longer being practiced in Egypt.At the beginning of the 20th century an exponential increase in population began and escalating demand for food ensured. Egypt planned to overcome the phenomenon of the slow rate of land reclamation and water shortage by implementing the following measures:

- development, augmentation, re-use exploitation of shallow and deep aquifers;
- irrigation improvement projects;
- demand management, minimizing loses, raising the efficiency of water management.

This drives governmental policy towards high production which require increasing crop intensification, greater input efficiency, reduced negative environmental effects, and efficient management of precious resources, mainly water for irrigation. The following on - farm soil - water - crop management techniques and practices are recommended to provide technological packages including proper agricultural inputs, mainly high quality seeds, introducing appropriate mechanization technologies and optimizing fertilizer and pesticide use to farmers with a special focus on small and medium size farms.

2. Water consumptive use in Egypt

Water requirements could be estimated for the old lands in the three agroclimatological zones of Egypt (Delta, Middle and upper Egypt) by using an irrigation efficiency 50-60% for surface irrigation, 70-80% for sprinkler and 80-90% for drip irrigation. Leaching requirement of 10-20% to be a side from salinization and to improve water distribution uniformity.

Seasonal water consumptive use by crop lands reached 29.75 billion cubic meters per year. Such value had been estimated by using a suitable crop coefficient. The distribution of this value between the different agricultural crops, are 66.6 - 22.7 - 10.3 - 0.4% respectively for field crops, forage crops, orchards, vegetables and medical plants. lt can be mentioned that field crop is the highest consumer of water between other agriculture sectors. Such field crops comprise about 61% of total cropped area.

By considering irrigation efficiency, the total irrigation requirements were found to be 49.58, 39.67 and 33.06 billion cubic meters per year under surface irrigation, sprinkler and drip irrigation systems respectively. The improvement of surface irrigation or introducing the modern irrigation systems, saves a huge quantities of water for the expansion of newly cultivated area for the national mega projects.

3. Land and water development in Egypt

In 1806, Egypt's population was at 2.5 million and cultivated land was at 2.5 million acres (1.0 acre per capita).

In 1917, Egypt's population increased to 12.5 million, with cultivated area at 5.3 million acres (0.4 acre per capita).

In 1952, population mark reached 21.5 million and cultivated land was at 5.5 million acres (0.25 acre per capita).

From 1981 until present over 1.6 million acres have been reclaimed at a rate of 100,000 acres per year - (0.08 acre per capita).

In order to face the issue of a spiraling population increase, the following measures have been taken into consideration:

- reclaiming and irrigating a total of 3.4 million acres of land, 1.4 million are in upper Egypt (the Nile valley fringe which begins from Assiout to Aswan and the Western Desert);
- the remaining 1.2 million acres under development for irrigation by the year 2002 are located in Sinai, the east and West Delta, and the northern part of the Nile valley;
- the last 0.8 million acres will comprise of suitable arable land in the Nile valley, the Delta fringes, Sinai and the Red Sea.

4. Irrigation methods and practices available in Egypt

Large, medium and small irrigation systems are applied in Egypt. Surface irrigation is dominating in the old lands (5 million acres). Half of the newly reclaimed areas (1.6 million acres) are sprinkled. Sprinkling is implemented mainly by semi-stationary system. Varies types of sprinkling machines and installations are applied depending on some specific features available. There are areas were stationary systems are built with permanent structures on the ground and sprinklers to irrigate perennial plants as well as field crops. The **Table 1** demonstrates sprinkler installation parameters generally available in the newly reclaimed areas.

Center - pivot irrigation machines are generally used in huge projects - this system is stationary - the only rotation elements are the cantilever arm.

Between 50-150 acres can be irrigated at a single position in terms of water pressures. Operation pressure limits are 3-6 bars water application discharge: 7-12 l/s application rate 4 $mm/h{\cdot}m^2$. Water distribution to the crops can vary according to the water quantities in terms of system's application. The system is equipped with sprayers for water dispersion. Water is delivered to the system where a hydrant and a pipeline are plugged in.

Drip irrigation is applied for vineyards, orchards and selective field crops. For installations used in the open fields and greenhouses:

- installations with Drip pipelines. These installations are used for irrigation of vegetables, flowers, and strawberries and orchards. It consists of (**Fig. 1**): water delivery pipeline; control head with equipment for water regulation and purification (hydrants, filters, etc.) distribution pipelines (1); dripping laterals (2); various fittings - rubber gasket (3); shortened nipple (4); normal nipple; suspending tape (5); cap (6);
- installation with smooth pipelines and drippers. These installations are used for irrigation of orchards and other crops grown at greater spacing between plants in a single raw. lt consists of (**Fig. 2**): water delivery pipeline; control head with equipment for water regulation and purification (hydrants, filters, etc.); distribution pipelines (1); lateral pipelines (2); drippers (3); various fittings - rubber gasket (4); nipple (5); T-piece; suspending hook and suspending tape (6); cape (7);
- installations with micro-sprinkler. These installations are used for irrigation of vegetables and flowers. It consists of (**Fig.

3): water delivery pipeline; control head with equipment for water regulation and purification hydrants, filters, etc.); distribution pipelines (1); micro-sprinkler laterals (2) with diameter of 20, 25 or 32 mm. With micro-sprinklers (3) attached at a regular interval from one another either directly into the pipeline or on a prop with hose, 4 mm in diameter, attached into the pipeline; various fittings - rubber gasket (5); nipple (6); T – piece; suspending tape and cape (7);

- installations with single-side spraver. These installations are used for micro-spray irrigation of vegetables, flowers, orchards and other crops. They are also used for improving the micro-climate. Of these crops through emission of very fine water particles fog. lt consist of the same parts as above only part (4) is changed by a single-side sprayers;
- Net filter (**Fig. 4 A**) - used for purification of water before it reaches the irrigation laterals of micro-sprinkler and drip irrigation installation. Flow rate 0.5 l/s; pressure 6 bars; retaining capacity-retains particles larger than 0.25 mm;
- fertilizer tank with dozing unit (**Fig. 4 B**). Used for injecting liquid chemicals and fertilizers into pressurized irrigation pipelines. Flows rate 2 l/s; pressure up to 6 bars;
- automatic membrane valves (**Fig. 4 C**). Used for regulation and protection of irrigation and water supply pipe systems and pumping stations. Most commonly used as inlet pressure regulators, outlet pressure regulators (inlet and outlet pressure) regulators, water reliefs valves, and flow rate regulators. Pressure up to 16 bars;
- puncher (**Fig. 4 D**). Used for punching holes with diameter of 4 mm in irrigation pipelines. The holes are used for attaching the drippers and the mícro-sprinklers.

5. Water management development

On - farm field investigations were conducted in two successive growing seasons (1996/1997 and 1997/1998) in an area of 2640 acres at three agricultural research stations representing the agronomic zones of Egypt (Delta, Middle and upper as shown in the attached map - **Fig. 5**), to evaluate some new techniques and practices applied to improve the on-farm management of three irrigation systems (surface, sprinkler and drip). The following topics demonstrate the results obtained.

5.1. Surface irrigation practices

The first topic covers the design of border irrigation for cotton crop at Nile delta clayey soil.

This investigation was conducted at Sakha farm Kafre El-Sheikh Province to suggest suitable design, border lengths and widths, different irrigation discharges and land leveling practices under cotton cultivation.

The results revealed that as irrigation discharge and boarder width increased the opportunity time decreased. The border length of 200 m gave the maximum opportunity time, while the border length of 50 m gave the minimum opportunity time of infiltration. Also, the results indicated that the opportunity time increased under traditional land leveling.

Concerning the amount of water losses, the results showed that the maximum amount of water losses were achieved from combination between border width of 5 m irrigation discharge of 2 l/s · m and irrigation run length 200 m under traditional land leveling.

Regarding the water storage efficiency, the data revealed that the highest values of water storage efficiency were achieved with border length of 50 m and 10 m, border width 15 m, irrigation discharge of 4 l/s·m under precision land leveling.

Therefore, ìt could be concluded that the ideal optimum condition case was detected from the condition treatment, irrigation discharge of 4 litres/s·m, 15 m border width and border length of 100 m under precision laser land leveling.

The second topic discusses the effect of irrigation intervals after flowering and potassium application timing on cotton productivity.

This investigation was conducting at the same area to study the effect of different intervals during the period from flowering tili picking and different K application timing on cotton yield the results obtained were summarized as follows:

- the highest water consumptive use value was obtained when K was added at flowering, while the highest water use efficiency value was found when K was added at planting;
- treatment of irrigation every 10 days from flowering combined with applying K at flowering obtained the highest value of water consumptive use while irrigation every 20 days from flowering combined with adding K at planting gave the highest value of water use efficiency.

5.2. Sprinkler irrigation practices

The first topic discusses the effect of available soil moisture depletion and sprinkler irrigation patterns on lentil plant in sandy soil.

Two field experiments were conducted in sandy soil at Ismailia Experimental Research Station to study the effect of available soil moisture depletion at 25%, 50% and 75% under isosceles and rectangular irrigation patterns on lentil plant characteristics, grain and straw yield.

The effects of irrigation pattern namely; isosceles, rectangular, equilateral and square on plant characteristics and yield of lentil.

The obtained data revealed that plant characteristics (plant height), number of branches/plant, number of pods/plant, weight of 1000 seeds and yield (grain and straw) of lentil plant gave the highest value when plant irrigated after depletion of 25% or 50% of available soil moisture without significant difference between two treatments, while the lowest values obtained when plants irrigated after of 75% available soil moisture.

With respect to sprinkler irrigation pattems, it was found that square and equilateral pattern gave the highest significant values for all studied parameters of lentil plant as compared with isosceles and rectangular patterns.

The second topic covers a field study conducted at the same area to evaluate the effect of different water application frequencies under sprinkler irrigation system.

Results revealed that the mean values of water application efficiency and percolation losses percentage were 77.70% and 22.30% respectively, while it was 66.94% and 33.06% respectively recorded from surface irrigation.

5.3. Drip irrigation practices

This topic discusses the effect of different soil textures and levels of available water on cotton yield and water utilization efficiency under drip irrigation system at Shandaweel Agricultural Research Station in upper Egypt.

The results indicated that the maximum seed yield was obtained from clay and silty soils irrigated to reach 100% of the available water.

Seed index increased under clay soil and watering to 100% of available water. Lint percentages were higher with clay and silty soils while sandy and calcareous soils reduced lint percentage.

Crop earliness was higher with sandy and calcareous soils than clay and silty soils. Watering to 75% of available water gave the highest values. The tallest plants were achieved under sandy and calcareous soils and watering to 75% of the available water.

Concerning the amount of irrigation water, the highest values were obtained under clay soil and irrigation to reach 100% of the available water followed by silty soil while the lowest values were with sandy soil and watering to 75% of the available water.

Clay and silty soils achieved the highest values of water utilization efficiency. Irrigation to 75% to available water gave the highest values of water utilization efficiency.

6. Conclusions

Based on the results of the investigation reported in this paper, the following conclusions are made:

- the improvement of surface irrigation or introducing modern irrigation systems, saves a huge quantities of water for expansion of cultivated area for the Egyptian national projects-to meet the ever increasing population and to close the food gap;
- concerning the water application efficiency under continuous flow, the data indicated that the furrow length and width have positive effect, while irrigation discharge has negative effect on water application efficiency;
- surface irrigation is a useful method under specified conditions, but precision land leveling is its prerequisite;
- sprinkler distribution pattern is determined depending on the operating pressure and wind speed;
- drip irrigation gives good results even when using relatively high salinity water. By this method, low moisture tension levels can easily be maintained throughout the growing season. After harvest, leaching with good quality water is required to lower the salt content in soil before sowing a new crop;
- the application of nitrogen and potassium - to various types of crops is beneficial - through the modern irrigation systems. This is one of the useful practices in the management of irrigated agricultural;
- a properly designed and installed filtration system will reduce hydraulic losses.

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Fig. 1 - Drip pipelines

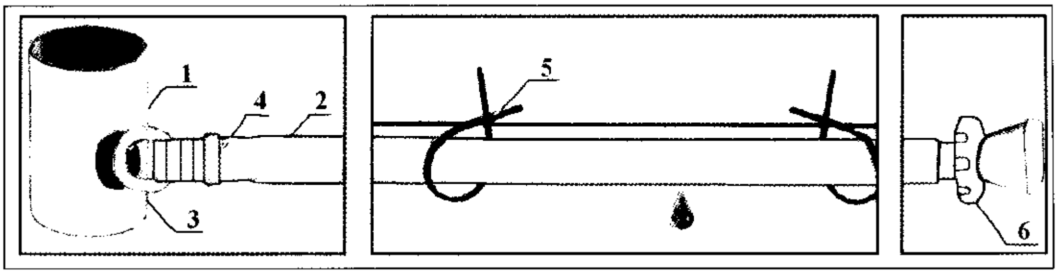

Fig. 2 - Smooth pipelines and drippers

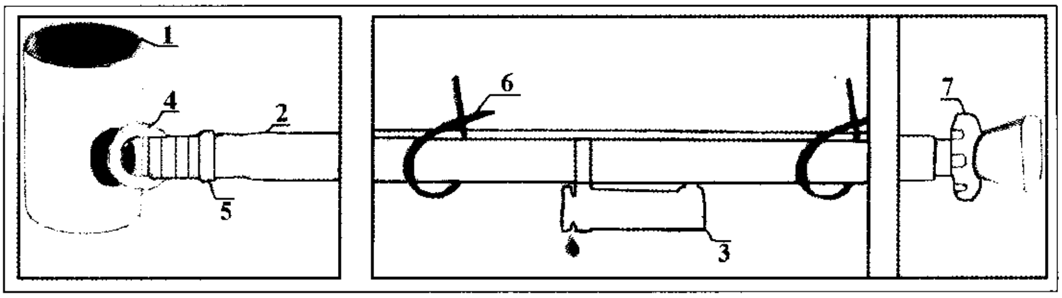

Fig. 3 - Pipelines with micro-sprinkler

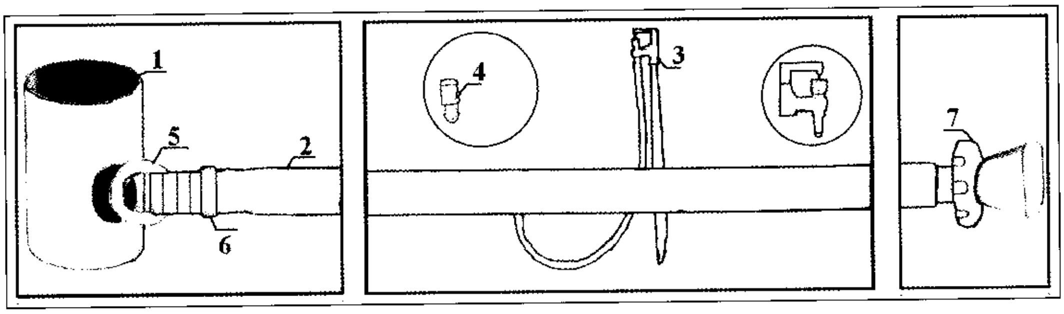

Fig. 4 - Other installation equipment

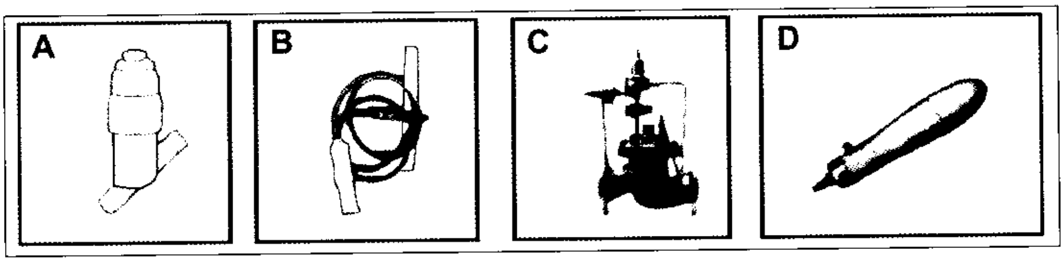

Fig. 5 - The map of Egypt

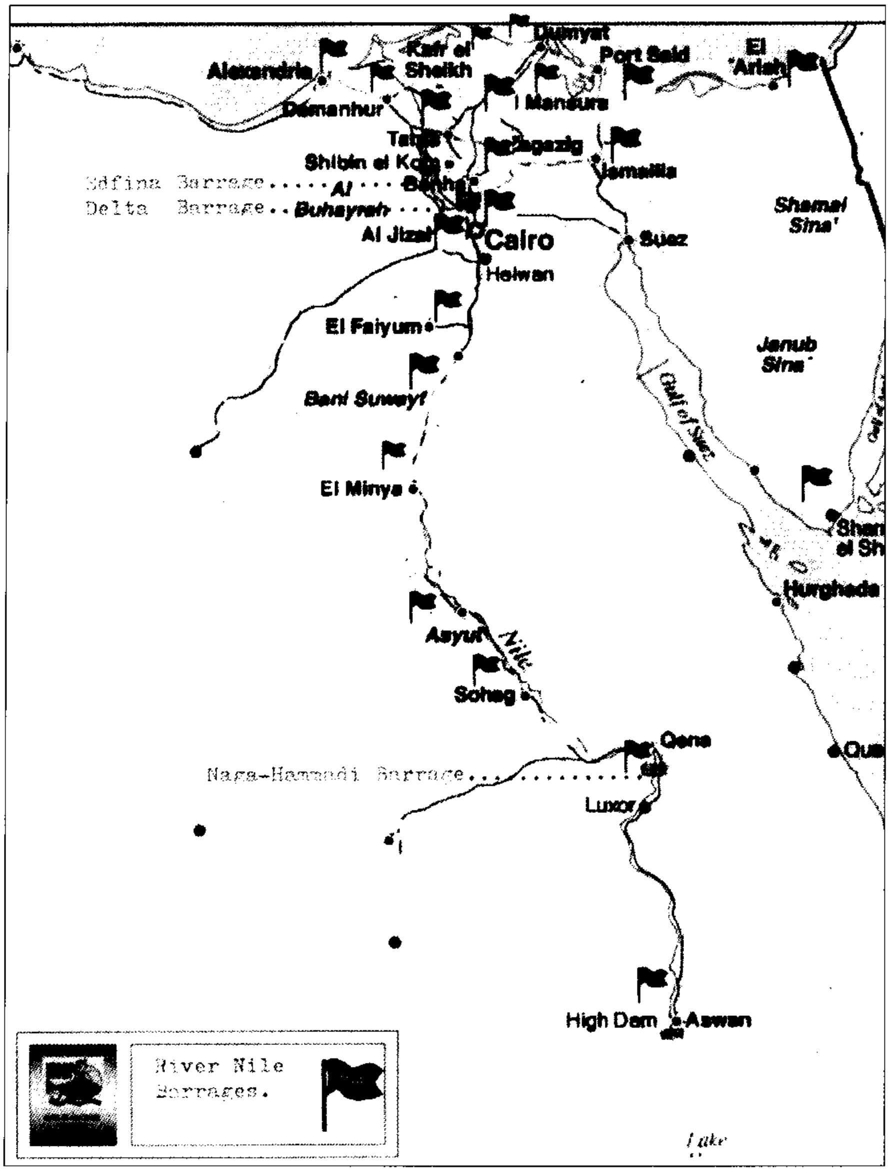

Table 1 - Sprinklers installation parameters

	INTENSIVE CROP	ORCHARD	SHORT CROP
Lateral (PVC) diameter (mm)	60	60	60
Distance between sprinklers (m)	18	12	18
Distance between laterals (m)	18	12.15.18	18
Flow rate (l/s)	5-6	4-4.3	6
Operating pressure (bar)	4-5	4-5	4-5
Sprinkler (n.)	15-30	11-17	15-30

DISCUSSION

Yoav SARIG

Israel

I have great respect for the Key Note Speakers, but I do not think they are giving us the right directives. What we have heard today are three technical papers; the third was to me a technical-type service on the drip irrigation method. I think there are far too many technical papers and, to my understanding, the original format was established to service a think tank group, to create challenges and directives. For example, I would like to hear the first three papers give explanations as to why there is a discrepancy between the amount of manure used in the US and in Europe. May be we are just engineers and we need some input from the agronomists, as Prof. Sevilla said. I can pose some questions, not just take, this is the system which is used. I'm from Israel, we develop the drip irrigation method, but there are problems even in my country. We can discuss the validity and economics of using drip irrigation, but maybe there are other methods. I would like to hear some more, to give some guidelines, because we should be the leaders. I'm sorry if I some are saddened by this comment, but I hope this will give some food for thought among the members of the Club.

Jaime ORTIZ CAÑAVATE

I appreciate what Dr. Sarig has said, because he suggests a way of thinking for future situations. Nevertheless, we have to understand also how the Key Note Speakers present the problem in the way they consider more suitable for our forum.

Alì M. EL HOSSARY

Egypt

Dr. Kenig's paper has been very useful, I would like to ask him about the best way of filtration for the system. You know we have so many problems to adjust a good filter system for the drip irrigation. Can you give us a short comment on this?

Elisha KENIG

The filtration problem is another subject for another lecture, so I will just give you a few notes. I think that the idea of the new dripper development will give us the possibility to work in a better way, in combination with the filtration system we have today. At the beginning of the season the reservoir is completely full of water, so there is no problem. Later on, as the season progresses, the water level in the reservoir falls and the concentration of the particles is higher. In other words, with a new project and no experience on what happens to the water, we will dilute, we will try to introduce drip irrigation into the system and into the land. Usually, when there is competition between two manufacturers they will compete on the filtration subject, they will try to reduce the price on it. When the filtration system is blocked we have to clean it once every half hour, not using the automatic machine, which can not overcome these procedures. The first solution is to have 6 or 7 filters instead of 5. As soon as you install the additional filtration, you reduce the discharge of each filter and the system can overcome it. This is the approach I would take rather than give the right solution for the beginning.

Uri M. PEIPER

Israel

I think that the creativity must come from here, rather then in the solutions given by the Speakers, who should just try to give a few ideas. Irrigation is only one part of the game. We actually use a technique called "fertigation": we bring water to the plant with all the nutrients. It was said that we grow less material in soil; this means that with the water we supply all the necessary *nutrient elements for the plants. If we work with this type of "fertigation", we have some run of water, which is scarce in the Middle East and in other areas of the world. Some of these nutritional materials are consumed by the plants. We want to recycle this water and we want to find out exactly how much nutritional material we have to add, before we start recycling.At the moment we use pH and EC to get some idea of the quality of the recycled water, but this is only a small part of the picture. To find the right one is the challenge for industry and for research.*

Gajendra SINGH

India

I want to pick up the point raised by Dr. Peiper. We have found in most cases that economy is based on saving on fertilisers. This is what we are promoting - even in a poor country like India. The manufacturing technique is accepted to the extent that everybody gets a 50% subsidy of all drip irrigation equipment, some of the poorest men and women get subsidies of up to 90%.

Richard O. HEGG

I return to the theme of this section: advancement in technology for input distribution. We have seen some very good perspectives at the technological level, e.g. - the very fine drip irrigation. We have also talked about the commercial fertiliser system we have for applying animal manure. I would like to emphasise the fact that engineers know how to apply all this. I would underscore the fact that we need to make progress in the development of new technology.

Jan PAWLACK

Poland

What is the investment cost if we compare drip irrigation to conventional systems? I'm not an expert, but I think that the advantages of drip irrigation are reduced water consumption and a reduction in soil salinity. Taking into consideration also the advantages, what is the difference in management cost ?

Elisha KENIG

If you compare drip irrigation to sprinkler irrigation it costs about 40-50% more. It is the most expensive system we have. If you know the conditions of the field, they kind of crop you are going to get and what kind of soil you have, then you can decide what sort of technique you are going to use, comparing one project to the other. From an operational point of view drip irrigation is very easy, because you don't have to work when you open the tap. For example, if you have a computer you can use it. I also mentioned fertilisation when I described water volume, because the whole system should be developed exactly where the water is. Thanks to what we can introduce into the water volume - at very good conditions - there are very small fluctuations. In fact if you compare sprinkler irrigation with a common interval of once a week, you notice that the water content inside the soil is very high after water application and very low before the next application; with drip irrigation in this small volume the fluctuation is very low. This is one of the reason why drip irrigation is more efficient. According to this system we must carry out fertilisation, but outside of this there are a lot of advantages: we can apply certain fertilisers at certain times, we do not need to use big machines to spread fertiliser everywhere to be efficient. The philosophy is completely different: applying small doses of water and fertiliser is far more efficient.

Alì M. EL HOSSARY

If we compare the economics of irrigation systems - drip, sprinkler and surface irrigation systems - you have to ask: "How much does it cost to produce 1 kg of product?".

Elisha KENIG

The drip irrigation system can use saline water, whereas if you use saline water with sprinkler irrigation you cause damage to the *forage. Do you remember the slides I showed you on pepper? It is cultivated using highly saline water. Using sprinkler irrigation in the same conditions, we are not going to get what we have. It will be completely different because when you use saline water inside this rated volume, the concentration of the solution itself, together with the fertiliser, is very low. Studies have shown that the plant can fit into it very evenly.*

El Hassan BOURARACH

Morocco

I want to ask if there are some errors in general, or if there is any damage to the crop using this kind of system and what the results are?

Elisha KENIG

I worked for the FAO in China and I did few irrigation projects using drip irrigation in several provinces. I often said: "This is very expensive, what we are going to do?" and the answer was:" If you don't try you will never know." Now we know for sure, that in very serious cases of very poor soil and water, drip irrigation has such high advantages that you cannot compare it to any other system. I think you can start using drip irrigation, if you want to increase any standard of living of small farmers in developing countries. You must know the technique and how to apply it, because it is unlike any other system. With drip irrigation also some agro-techniques should be changed, for example the arrangement of the planting population in the field. In fact it is presumed that we have a high vegetable population in the field, with very light soil. For that reason we have to arrange the plants very closed. Thinking about the discharge capacity of the dripper and the crop we have in the field, all this should be fitted together very carefully.

Franco SANGIORGI

The problem is that we are trying to explain how to use the input in the best way and, at same time, we say we need to produce more. For instance, in our country to get 12 tonnes of maize per hectare, we need to put 300 kg of nitrogen per hectare. This will increase pollution, because you have a quite high release of this unutilised product to the environment. We need to increase the yield because we have to pay for a more sophisticated technology, but then we have to face the side effects that give us a new challenge: how to cope with this new problem.

Alì M. EL HOSSARY

In modern irrigation systems, especially in drip irrigation, the inputs are well controlled. I read here from this paper that fertiliser conception is reduced from 40% to 30% in growing cotton, therefore pollution will decrease and even the use of fertiliser will be reduced.

Franco SANGIORGI

I agree with you, but the drip irrigation system is related to a high investment cost. So, the question is: in order to save nutrients, you pay a lot of money to computerise the system.

SESSION 2

Transfer of technology from developed to developing countries

Chairman: Derek H. Sutton, U.K.

Transfer of technologies from developed to developing countries: experiences and results in Asia and the Far-East. The case of Korea

by ***Kyeong Uk Kim*** and ***Chang Joo Chung***

Korea

1. Introduction

Korea has achieved successful farm mechanization over last 37 years. Starting in 1962, Korea has executed a series of the five-year economic development plans that takes as its focus the industrialization of the country. Emphasis on industrialization and the consequent growth in non-farm sector stemming from the successful economic planning has provided off-farm employment opportunities for farm people. It was accompanied by heavy migration of farm people into new industries like auto making, ship building and electronics, resulting in a shortage of farm labor force. The shortage of farm labor force, however, had to be replaced by any means to produce food for a rapidly growing population of the country. It was recognized that farm mechanization was the only way to replace the decreased farm labor force and meet the domestic production requirement.

In order to promote the farm mechanization more effectively, agricultural machines suitable to local farming conditions must be made easily available. In other words, various types and sizes of agricultural machines could be locally manufactured and distributed to farmers.

At the beginning of the farm mechanization, however, Korea was not capable of producing powered agricultural machines. Powered machinery utilized for agricultural production was limited to stationary single-cylinder kerosene engines until the introduction of power tiller in 1961. Starting from such a poor industrial foundation, the farm machinery industry has grown up to one of the major manufacturing industries in Korea, now being capable of producing power tillers, tractors, rice transplanters, combines, speed sprayers, cultivators, grain dryers etc. In 1997, a total of more than 321,000 units of agricultural machinery was produced in Korea as shown in **Table 1** [1].

During the industrial development, manufacturers of agricultural machinery have suffered from the lack of technology both in design and manufacturing. To solve the poor technology problem and improve the production facilities, import of technology from the developing manufacturers under the technical collaboration agreement was inevitable although it was conceived to be technical subjection rather than technical collaboration literally.

The import of technology may be a kind of a must course that the developing manufacturers need to take to upgrade their level of technology before they become self-reliance technologically. Whether or not it will affect positively the technological advancement in the long run depends mainly on how the manufacturers can utilize the imported technology.

The developing manufacturers need to make themselves ready to accept the new technology and make best use of it for the advancement of their technology.

Korea has a long experience of importing technology from foreign agricultural machinery manufacturers. The import of technology has made a great contribution to the enhancement of technology but many restrictions on marketing activities for the machines produced under the technical collaboration agreement as well. The technology transfer between the developing and developed manufacturers must have a beneficial effect on both of them. Some of the experiences and lessons learned during the technology transfer will be addressed from the standpoint of the developing manufacturers.

2. Technical cooperation

In 1962, the Daedong Industrial Company, the largest agricultural machinery manufacturer in Korea, started producing power tiller in technical cooperation with the Kuboda Heavy Machinery Industry in Japan. This was the first technology transfer made for the agricultural machinery industry in Korea. The technology transfer was in fact a kind of trading of the technology between the developed and developing manufacturers under the technical collaboration agreement.

In the 1960s, the local manufacturers of agricultural machinery in Korea did not possess the technology enough to produce powered agricultural machinery independently. Therefore, importing the technology from the developed countries was inevitable to enhance the technical capability of the manufacturers and to promote the industry.

Following the power tiller, tractors, combines, farm engines and rice transplanters were also produced in technical cooperation with foreign agricultural machinery manufacturers from Japan, Italy, Germany and England. **Table 2** shows the import of technology made under the technical collaboration agreements in the 1970s, the beginning period of the farm mechanization in Korea [2].

Although the technology transfer was made under the technical collaboration agreement, it was not a kind of charity business in which the developed manufacturers supply unconditionally the developing ones with the necessary technology. It should be noted that the technology transfer is practically a commercial transaction.

The technical collaboration agreement usually specifies:

- initial down payment for technical fee that covers the cost of all the documentation including the drawings, testing and inspection manuals;
- royalty on sales;
- royalty on patents;
- term of agreement;
- range of technology;
- penalty on violation of agreement;
- termination of agreement;
- other provisions that must be obeyed.

The term of agreement is usually 3 or 5 years and renewable. The initial down payment is about US$ 50,000-100,000. The royalty is usually 3-5% of the total sales of machinery or US$ 200 for each machine sold under the technical collaboration agreement. The patent fee also should be paid separately if it is required. The term of agreement, initial down payment and royalty vary depending on the kinds of machinery and manufacturers.

In addition to these formal statements of the agreement, there are several conditions imposed by the technology transferor. These conditions restrict the utilization of the imported technology, development of associated technology and marketing of the machines produced under the agreement. Some of the conditions are often difficult to be justified morally and revealed publicly.

This may be the reason why the agreement on these conditions is called a behind contract.

Examples of such conditions are:

- the technology transferee shall not export the machinery produced under the agreement or may export them only to approved regions;
- after the termination of the agreement, the transferee should not utilize the same technology any more;
- the transferee must purchase the key components of the machinery to be produced. The transferor may change the supplying prices of such components;
- the transferor may restrict the effort of the transferee to develop the associate technology independently;
- under the agreement, a sister model should not be developed.

Under the technical collaboration agreement, the transferor provides the drawings of assemblies, parts and jigs necessary to manufacturer the machinery. Technical training for the test and inspection is also provided. Tech nical supervisors are often dispatched to solve the problems occurred in the production lines. However, these are not enough for the transferee to utilize the technology directly for the productions. The drawings provided to the transferee are not detailed enough for the productions. In other words, the drawings do not contain any detailed information that must be known when the parts are to be machined. Consequently, the parts could not be assembled although they were machined exactly as the drawing indicates. The technologies needed to solve this kind of problem are machining methods, assembling procedures, standard work process, standard data for accuracy, etc. However, any information on these technologies is seldom provided under the technical collaboration agreement. It is also true that some of these technologies may not be expressed in a written form. In many cases, they may be transferred by personal communications, which are informal rather than formal channels. The technology transfer through the informal communications differs from case to case. In other words, it differs depending on the company, kinds of machines, country and, most of all, characters of persons involved. More informal communications or many trial and errors may need before the transferee can make best use of the technology transferred. It is also very important for the transferee to have a proper technical capability so that he can accept and utilize a new technology.

As described above, although a technology transfer is made in the form of technical agreement, it is still a commercial business. That means the transferor is likely to consider the transferee as a potential competitor in the future markets. Therefore, the implicit intention of the transferor to keep the transferee under his control may be naturally reflected on the technical agreement.

Consequently, the technical agreement is apt to become a unilateral agreement for the transferor.

3. Lessons

In general, the most simple and easiest way of enhancing the technical capability of the developing manufacturers may be to import the necessary technology from the developed manufacturers through the technical collaboration agreement. Of course, importing the technology could be effective as mentioned previously when the developing manufacturers are ready to accept the new technology from the technical and economical standpoints. The localization of the production usually follows the importing of the technology. In other words, the developing manufacturer may import most of the parts of the machine associated with the imported technology at the beginning and gradually localize them until the whole machine could be assembled using the parts locally manufactured. The farm machinery industry in Korea has followed the same steps. This method of technology transfer has been successful in improving the production capability of the manufacturers. However, it must be noted that the localization of technology is relatively simple and a matter of time and skills of technicians. The localization is not concerned with the engineering technology but mainly with the production technology so that, most of cases, it has failed to accumulate the technologies necessary to design or develop new products for the future. The engineering technology, therefore, must be acquired at the same time during the localization process. This requires a continuous effort and a large amount of time and money that may be difficult for the developing manufacturers to invest. Whenever new products come out, importing their technology and localization of them may be less expensive and risky than developing their own products by using poor engineering technology. However, without securing the engineering technology for design, the developing manufacturers may not be independent from the technical subjection to the developed manufacturers and eventually they will disappear in the future market.

Although Korea has had a long experience of technology development over last 35 years, most of it is concerned with the localization of imported technologies under the technical collaboration agreements.

By doing so, the production technology has been advanced to the same level that most of the developed agricultural machinery manufacturers in the world have reached. However, as mentioned previously, the production technology may not be a key factor in developing of new products. In order to reflect customer's demands quickly on the new products, the design technology must be developed as well.

The lack of design technology, particularly the system design for the integration of a whole system may be a problem that has to be solved urgently to upgrade the technology level of the Korean agricultural machinery industry.

The lesson from this experience is that both the production and engineering technologies must be developed at the same time although no matter how the latter costs. In addition, the technology for testing and evaluation of the products also must be developed. As the production technology becomes equipment-dependent, purchasing new production facilities may increase accordingly the level of production technology.

However, the technologies for design, testing and evaluation differ. It becomes difficult or impossible for the companies, particularly for a company considered as potential competitor, to purchase such technologies. Even though it could be possible, it costs a tremendous amount of money so that the products associated with imported technologies could not compete with those produced by the technology transferor in the markets.

4. Conclusions

The technology transfer in these days must be regarded as a commercial transaction. It means that the technical transfer should be benefit to both the technology transferor and transferee and satisfy their mutual interests. It may not be expected for the transferee to obtain all the technologies that he needs through the technology transfer. However, it is the only way through which the developing manufacturers may enhance most effectively the level of their technical capability.

The technology transfer is made in the form of technical collaboration agreement and mainly concerned with production technology. However, the technical collaboration agreement is insufficient to acquire all the technology necessary for the production. There still need technologies that may not be transferred through any written documentation. Technology development for design, testing and evaluation must also be pursued at the same time with the production technology.

Development of the production and engineering technologies simultaneously is one of the lessons that Korea has learned through the long experience of technology transfer. Conditions of the collaboration agreement for the technical transfer are difficult to argue on their fairness. Even though some of them may be unfair from the moral standpoint, there is no way for the developing manufacturers to avoid such unfair deals if they need the technology desperately.

The more important thing is how effectively the developing manufacturers could utilize the imported technology. Maintaining good personal communications with the technology transferor is also an important factor for the successful conduction of technology transfer.

Different forms of the technical collaboration or technical transfer must be considered for the future to get more beneficial relationship between the technology transferor and transferee rather than feeling a kind of discontent at the end. Joint adventure or share of role may be one of such forms of technology transfer.

The joint adventure is to invest together for the technology development and share its result. The share of role is that manufacturers take different roles in producing products depending on their technical capabilities. In order to survive in a global competition era, more close collaboration between the developed and developing manufacturers must be maintained domestically and internationally.

References

[1] **Farm machinery yearbook**, 1998. The Korean Society for Agricultural Machinery.

[2] **KIST**, 1977. Study on the promotion of agricultural machinery manufacturers.

Table 1 - Production of agricultural machinery in 1997

MACHINERY	PRODUCTIONS (unit)
Power tiller	90,012
Tractor	24,487
Rice transplanter	55,514
Binder	5,250
Combine	7,863
Cultivator	53,446
Speed sprayer	4,904
Grain dryer	9,773
Other	69,654
Total	320,903

Table 2 - Import of technology from foreign agricultural machinery manufacturers

MACHINERY	TECHNOLOGY IMPORT FROM
Power tiller	Kubota Heavy Machinery Co., Japan
	Yammar Agricultural Equipment Co., Japan
	Iseki Agricultural Machinery Co., Japan
Tractor	Fiat Tractor Co., Italy
	Ford Tractor Co., UK
	KHD, Germany
	Kubota Heavy Machinery Co., Japan
	Yammar Agricultural Equipment Co., Japan
	Iseki Agricultural Machinery Co., Japan
Rice transplanter	Kubota Heavy Machinery Co., Japan
Combine	Yammar Agricultural Equipment Co., Japan
	Mitsubishi Corporation, Japan
	Iseki Agricultural Machinery Co., Japan
Mist blower	Kyoritz Agricultural Machinery Co., Japan
	Fuji Robin, Japan

by ***Wang Maohua, Zhang Lanshu and Geng Chengxin***

P.R. China

1. The situation and trends of agricultural mechanisation in P.R. China

Out of China's total population of 1.25 billion, over 0.9 billion live in the countryside. About 70% of all rural labourers are engaged in agriculture. Therefore, the Chinese government has given a great deal of attention to agriculture, and especially to grain production. Since the economic reform of 1978, agriculture in China has seen rapid development.

The total output value of farming, forestry, animal husbandry and fishery has increased 3.2-fold, basically solving the problem of feeding the entire population.

Throughout the country, rural areas are generally speaking in a period of transition from simply having enough food and clothing toward being comfortably off. But China is still in the development stage of converting from traditional farming to modern agriculture, with a low share of per capita resources and low productivity.

There is still a wide gap between China and the developed countries with regard to agricultural science and the average technology level, as well as in the level of scientific and cultural instruction of farmers. It is of vital importance to redouble our efforts to overcome the various difficulties and chart a route toward sustainable agricultural development.

1.1. Development of agricultural mechanisation between 1949 and 1980

The development of agricultural mechanisation can be divided into three stages. In the Pioneering period (1949–1957), which followed the founding of the new Republic, the government devoted considerable effort to the diffusion of improved farm tools in rural areas in order to recover agricultural productivity, and started investigating methods for agricultural mechanisation in state-owned farms. The tractors and farm machinery were mainly imported from the former Soviet Union and from Eastern European countries. Many experts and technicians from those countries provided technical services and manpower training. State-owned mechanised farms were quickly established through reclamation for cultivated lands, and state-owned tractor stations were run on a trial basis. The first generation of Chinese technicians, engineers and managers came out of the mechanised State farms. They subsequently contributed a great deal to speeding the mechanisation of farming in the country.

The initial development and adjustment period went from 1958–1965. In this period, the directions of development and the guiding principles and strategies for agricultural mechanisation were outlined, farm tools were vigorously reformed, state-owned tractor stations were established to investigate the use of agricultural mechanisation services in certain areas to replace man- or animal-powered tillage.

During the period from 1966 –1980, agricultural mechanisation experienced high-speed development for the first time. The overly ambitious goal of “Achieving agricultural mechanisation by the year 1980” was proposed to guide the development. A series of countermeasures and administrative measures were explored and adopted to speed up the agricultural mechanisation process.

The total farm power had reached 147.4 mil. kW in the country, and the tillage of 42.4% of cultivated land was mechanised in 1980.

In summary, the period between 1949 and 1980 saw a preliminary boom of agricultural mechanisation in the country. Both positive and negative experiences were accumulated in investigating suitable pathways for its further development. A system of national farm machinery industry was created.

By the end of 1980, there were 1829 farm machinery manufacturers around the country and 2366 county-level manufacturing and repair workshops were established to provide services for farmers in local areas.

The local industries contributed to the improvement and production of farming tools and machinery, acting as incubators which promoted the set-up of rural manufacturing enterprises around the country in the 1980s. An entire system of management organisation and services, as well as research and educational institutions devoted to agricultural mechanisation, was established from the central government down to the county level.

Many valuable lessons were learnt from problems such as: a lack of understanding of China's natural and socio-economic conditions which led to impractical forecasts that were overly ambitious and hasty; violations of natural objective economic laws, abuse of administrative measures and extensive mass movement; implementation of a planned economy, which only permitted unified management by the state and collectives, but did not allow management by individual farmers; and agricultural mechanisation that could not bring greater economic benefits to the farmers.

1.2. Development of agricultural mechanisation between 1981 and 1998

The initial period of the economic reform which started in 1980 prompted a general reevaluation of the development of agricultural mechanisation. Since 1982, the state has allowed farm machines to enter the market as commodities.

Farmers now have the right to purchase and manage farm machinery. At the same time, a two-tier management system has been adopted which is mainly based on household contract management, combined with collective ownership of large production assets as well. Thus, a multi-ownership economy has gradually formed which is primarily reliant on the state, the collectives, and individual farmers for the purchase and management of agricultural machinery.

In 1997, 10.81 millions tractors were run by farm households all over the country, accounting for 97% of the total number of tractors in use. During the period from 1981 to 1985, the number of small tractors increased rapidly, while the number of large and medium-sized tractors declined. In fact, the mechanisation level of cultivated land in the country as a whole decreased to a certain extent. By 1986, it had been restored to the level of 1978.

Following the reconstruction period, agricultural mechanisation and farm industries developed smoothly. The total farm power and mechanisation level of cultivated land have seen rapid development, in line with the actual conditions of the country. Some data about the development are given in **Tables 1, 2** and **3**.

As the century comes to a close, the agricultural machinery industry in China has reached a considerable scale. Improvements in product quality, optimisation of the organisational structure and the upgrading of the development capability have been deployed to meet the new challenge. New types of agricultural machines with superior scientific and technological content are rapidly being developed. A complete system for managing and servicing agricultural machinery has been established in China. A comprehensive base for the research, development, testing and appraisal of agricultural machinery has been reorganised to investigate suitable routes for the development of China's agricultural mechanisation.

1.3. Major problems

The structure of agricultural machinery needs to be adjusted, as there is currently insufficient capability for producing larger-sized tractors with advanced accessory implements, as well as an inability to meet the structural reconstruction needs of the agricultural industry.

The agricultural machinery manufacturing industry is too dispersed and small in scale. Many of the manufacturers operate using backward technology, with little variety and of poor quality. They do not meet the requirements for speeding up the development of agricultural mechanisation.

The research and development of agricultural machinery is conducted at an inadequate level, with insufficient financial inputs and technical know-how. It is not in line with the requirements for the scientific and technological progress of agricultural mechanisation.

Some of the laws and regulations are outdated and have led to inappropriate adjustment and control at the macroscopic level. They are thus not relevant to the requirements of the present market economy system.

2. Transfer of farm machinery technologies from the developed countries to China

2.1. Status of the world's farm machinery industry in relation to the Chinese market

2.1.1. China's imports and exports of farm machinery and its international technology exchange have been developing in concert with the reform, and opening up to the outside world since 1978.

The farm machinery exhibition held in October 1978 in Beijing, which involved companies from 12 countries, was the first large-scale international farm machinery fair since the founding of new China in 1949. It attracted attention not only from farm machinery firms and technical circles in China, but also from many government bodies at that time. The fair provided an opportunity for the Chinese people to learn of the latest developments in global farm machinery technology, and to recognise the gap between themselves and the rest of the world. Most of the equipment exhibited at the fair was purchased by the Chinese government, thereby producing an extensive and far-reaching impact on China's farm machinery industry. The fair ultimately marked the beginning of the exchange and co-operation between the Chinese farm machinery industry and its global counterparts.

In 1978, China imported a complete set of large tractors and matching farm tools for the first time, from the US manufacturer John Deere, and staged a large-scale demonstration on using the modern farm machinery at a "Friendship Farm" in Heilongjiang province.

The demonstration showcased technologies characterised by lower labour requirements, higher yield and higher benefits. This set of machinery was capable of completely mechanising the entire farm production process from tillage, irrigation and harvesting to product storage. Later, a complete set of herbage production and feeding machinery from John Deere was introduced into the Inner Mongolia Autonomous Region, and demonstrated the mechanisation of animal husbandry.

2.1.2. The purchase and importing of the above-mentioned machinery promoted China's understanding of global farm machinery technology and enabled it to acquire useful experience, thus serving as a new starting point for farm mechanisation in China.

In order to develop advanced technology and improve the backward situation of China's farm machinery industry, China first of all imported the design and manufacturing technology of John Deere's 1000 series grain combines in August 1981.

The production technology was introduced into the Jiamusi Combine Factory in Heilongjiang Province and into the Kaifeng Combine Factory in Henan Province. That was the earliest and largest farm machinery technology import project. Later, in 1984, the production technology for 160-HP large tractors and medium-sized tractors from John Deere was introduced to tractor manufacturers in Shenyang, Tianjin and Changchun. John Deere provided extensive training programmes for design and manufacturing engineers and technicians in those factories and at its overseas branches.

At the same time, the China First Tractor Factory imported the production technology of the FIAT 90 series tractors. The first promotion of the large-scale technical transfer of farm machinery from developed countries into China laid the foundations for international co-operation in the field of agricultural mechanisation.

2.1.3. China is a big agricultural country and represents a huge potential market for the world's farm machinery. The US manufacturer John Deere, one of the first to target China's farm machinery market, has been patiently exploring the Chinese market for the past 20 years. China purchased the first complete sets of machinery from the company in the late 1970s, imported its combine production technology in the 1980s, and formed a joint venture in May 1997 - the John Deere-Jialian Harvesting Machinery Company (JDJL), of which the company holds the majority (60%) of shares.

In the past two years, JDJL has achieved great success and accumulated valuable experiences for the joint venture based on local conditions.

The annual output has reached 3000 units in total, including 500 units of large-scale model 1075 grain combines (5 kg/sec) and 2500 units of smaller-scale model 3060 combines (2kg/sec). Except for the imported engines on the 1075 model, nearly all components of the combines are manufactured domestically. Therefore, the production costs are much lower and good marketing opportunities have emerged.

In consequence, the co-operation between John Deere and China has entered a new stage. Since the early 1990s, China has successfully matched the household contract system with large-scale socialised production, thereby charting the route for the commercialisation and socialisation of farm mechanisation services.

The process of rural industrialisation and modernising farming has accelerated, and in consequence the demand for small-scale farm machinery in China has now peaked, and there are clear signs of growing demand for large and extra-large models. Some of the leading farm machinery manufacturers from around the world have been watching China's farm machinery market and have gradually made their way into China. These include companies such as Case, New Holland, Massey Ferguson, Kubota, Yanmar and Hege, etc.

According to their individual competitive advantages, they have gathered together in the Chinese market for an "international competition" with free demonstrations and trial use of farm machinery and implements, bidding for credit projects of which China is the buyer, and for technical co-operation with China:

- in addition to the John Deere-Jialian Company, the New Holland Company sold 363 units of 175-HP tractors to Heilongjiang Province this year and has decided to form a joint-venture - Harbin New Holland Beidahuang Tractor Company Limited - with the Chinese counterpart in March of this year. New Holland will hold a 70 % share. It is planned to start the corporation with the installation of 100 – 180 HP tractors for the domestic and overseas markets;
- the Case company ranked third in tractor sales to the Chinese market. It set up an assembly factory for engineering machinery in Shanghai several years ago, and has been negotiating the co-operative production of Model-515 combines with the Siping Combine Factory in Jilin Province;
- the John Deere company has been demonstrating its Model-7810 185-HP tractor, Model-726 double harrowing machine, and Model-450 seed drill in a state-owned reclamation farm in Xinjiang Autonomous Region, and is negotiating with state-owned farms in Xinjiang concerning the possible ordering of up to 1000 extra-large tractors and farm machinery. John Deere's engineering machinery is also expected to play a role in the development of western China;

- in order to corner the prospering market of rice production machinery, the Yanmar company of Japan formed a joint-venture with Wuxi City, Jiangsu Province in October 1997, which is expected to start formal production on August 8 this year. Its target for the first phase is to produce 3000 "People Brand" semi-fed rice combines per year, with 30% of the parts manufactured in China;
- the Kutoba company of Japan has shifted its focus from Beijing towards the south, and has set up a mono-capital firm in Suzhou City, Jiangsu Province, thus competing with Yanmar company for the semi-fed rice combine market in south-east China;
- farm machinery companies from South Korea are also actively involved in exploring markets for combines, rice planters, powered tillage machinery, and agricultural vehicles in south-east China, Shandong Province, Zhejiang Province, and some other areas. They are seeking development opportunities for exploiting their competitive advantages in the Chinese market, by providing an appropriate price and technology level;
- the Sanjiu company of Taiwan, a manufacturer of low-temperature grain dryers, set up a mono-capital factory in Shanghai to meet the demand for mechanised post harvest rice drying. Subsequently, in 1997, the Jinzi company of Japan set up a mono-capital firm in Wuxi City, Jiang Province. The main markets of these two companies are concentrated on post harvest paddy equipment requirements in the coastal provinces of south-east China.

2.2. Demand trends in China's farm machinery market

2.2.1. Of the 50 years that have passed since the founding of the People's Republic of China, the first 30 saw agricultural mechanisation in its initial phase, with technology mainly introduced into China from the former USSR, and later produced by China's own capabilities with a predominance of medium- and small-sized machinery.

Co-operative agricultural production in China took a roundabout course. Owing to the adoption of the people's commune system in the late 1950s, fields were combined and farmers worked collectively. With the support of the government, the promotion of farm mechanisation relied mainly upon the resources of the state. In the past 20 years, however, China has promoted a market economy-oriented reform of the rural economic system by practising household contract management of the land.

Due to a relatively lower land surface and the greater number of people, the amount of land cultivated per capita is only about 0.11 ha, and the household operations are on a small scale.

In the early period of the household contract management system, the economic level of the farm households was low and it was not possible to devise a system for the management and utilisation of large-scale farm machinery. This made it impossible for farm households to purchase and use the high-priced large foreign farm machinery. Only small farm machinery was feasible for them to use.

In consequence, farm machinery in China in the 1980s consisted mainly of small models. China has devised a great many innovations in this regard, e.g. small hand-driven & four-wheeled tractors, paddy tillage machines, and small tractor back-packed combines.

2.2.2. Starting in the early 1990s, Chinese farmers essentially solved the subsistence problem of having enough to eat and wear.

The rural economy started to recover, with a rapid speeding up of the rural industrialisation process. Large amounts of surplus rural labour started to pour into urban industries, trade, and the service industry.

Subsequently, households managing large areas of land started to appear in the countryside. In the early 1990s, combines were used for trans-provincial mobile harvesting of wheat from the south to the north.

The operation time for large and medium-sized farm machinery was extended and their profitability increased. From this practice, the Chinese farmers gradually found an appropriate mode of operation for the commercialisation and socialisation of farm machinery services.

Thus the scale of the farm machinery operation was expanded, creating a prospective market for large and medium-sized farm machinery.

In the past 10 years, large and medium-sized tractors and combines have regained vitality for development. At the same time, a large number of old machines have had to be replaced.

The market for large and medium-sized farm machinery has therefore started to grow in China. However, due to the inherent weaknesses of China's farm machinery industry, with enterprises that have long been operating under a planned economy system and a lack of long-term market demand, the imported production technology for large tractors in the early 1980s was not a predominating force in terms of quality and quantity.

The introduction of combines, though successful, met with many difficulties due to the common problems of the state-owned enterprises. The development of China's farm machinery market is a gradual process.

The current demand for large and extra-large farm machinery in China is rather limited. For the Chinese enterprises, production of small lots or even single units of large farm machines is uneconomic on the one hand, and cannot ensure product quality on the other. China is unable to meet its own demand for large farm machinery, thus creating market opportunities for international firms with respect to large and extra-large wheeled tractors and large combines. **Table 4** shows the domestic manufacturing capability for medium and large-sized tractors in 1990s.

2.2.3. In terms of the structure of farm machinery, the domestic production of large and medium-sized machinery and tools is at a mature stage and essentially able to satisfy the demand of the farmers for the production of wheat, the staple crop of Chinese agriculture.

The principal production steps, such as tillage, seeding and harvesting, have by and large been mechanised. However, the production of rice and corn, which are China's first and third most important crops respectively, is labour-intensive and has a low level of mechanisation.

Rice production is mostly found in economically developed areas where rural labour is quickly shifting to urban areas. The increased cost of labour and the pursuit of comfort by young farmers has created a pressing need for the mechanisation of rice production.

Generally speaking, the first agricultural mechanisation campaign, i.e. the mechanisation of wheat production, was essentially completed after 20 years of effort. The second campaign, i.e. for the mechanisation of rice and corn production, is already under way with concentrated effort. This indicates that the development of China's farm machinery has entered a new phase. Growing rice seedlings, transplantation, harvesting and drying are the four main steps in rice production. Factory seedling raising has been universally accepted. Drying can be done using existing dryer models. Transplantation and harvesting are the two most difficult, yet important steps in rice production that need to be mechanised.

The structure of the cultivated land and the cultivation system are rather complicated in China. There are single cropped rice areas in the north, and wheat-rice continuous cropping areas and double cropped rice areas in the south. The climate, topography and traditional cultivation methods in double cropped rice areas place many rigorous requirements on farm machinery, some of which are problems yet to be solved in the history of global farm machinery.

China has a total of 32 million hectares of paddy fields. The mechanisation of rice production has created a huge market in China and is the most prominent field for research and development, technology transfer and machinery sales by foreign firms.

Corn is the third important crop in China. Transplantation, intertillage and harvesting have a low level of mechanisation. In the double continuous cropping areas, corn harvesting and the handling of corn stalks after harvesting pose major problems and are badly in need of mechanisation. This is also a huge market for farm machinery.

During the reforms of the past 20 years, much importance has been attached to the research and development of mechanisation for wheat production. On the other hand, the research and development of machinery for rice and corn production has received insufficient attention. In consequence, there was a lack of study of the basic theory and preliminary research and development, the decision makers were consequently unable to make predictions concerning the mechanisation of rice and corn production, and the organisations for the research and development and production of farm machinery found it difficult to handle the rapidly increasing demand of farmers. Without a doubt, this provides a rare opportunity for international farm machinery firms to enter the Chinese market of rice and corn production machinery.

2.3. The prospects for co-operation between chinese and foreign farm machinery firms

2.3.1. The co-operation between Chinese and foreign farm machinery firms can take many forms, e.g. sales of commodities and co-operative production (joint-ventures or mono-capital enterprises). With regard to commodity sales, the current practice consists mostly of involvement in buyer's credit international bidding.

This mainly comprises loans from the World Bank, inter-governmental loans, commercial loans, and compensation trade. These are mostly state-owned farm development projects, which provide opportunities for large orders on a temporary basis. Generally speaking, however, that is only a small part of the huge Chinese market.

The problem of foreign businessmen with regard to retail trade is that they need to have a through understanding of China's status and conduct a long-term market investigation.

China is a developing country with low per capita income. In fact, the average income of farmers in 1998 was US$ 315 per person, which ranks among the lowest in China and is far lower than that of the urban residents. It will be impossible for China to adjust the tariff to a very low level within a short period of time, before joining the World Trade Organisation (WTO).

High prices of foreign farm machinery, when they reach the Chinese market, will be prohibitive for Chinese farmers, limiting the opportunities for doing business. In addition, Chinese farmers are increasingly annoyed by the practice of dumping whole machines at low prices but selling spare parts at high prices. They are very vigilant of this practice. Therefore, the feasible route is to set reasonable prices and patiently explore the market.

2.3.2. From a long-term point of view, co-operation between Chinese and foreign firms for the manufacture products in China and for the localisation of products have been successful in exploring the Chinese market.

During the 20 years of reform and opening up to the outside world, many international co-operation projects in the field of farm machinery — and in particular two technology transfer projects for large tractors and combine harvesters — were unsuccessful, mainly due to reasons internal to China. However, this form of co-operation does have its own inherent weaknesses.

To a certain extent, it is correct to say that the Chinese economy is more backward in management than in technology. That was why the economic reform was initiated. The reforms and the opening up to the outside world require not only opening the doors to technology, but more importantly to new management methods, so that advanced management experience can be absorbed from developed countries.

Technology transfer contracts have strict restrictions. The two parties of the contract are actually competitors on the marketplace. Therefore, it is impossible for this type of co-operation to be very close.

The technology transfer from John Deere to the Jiamusi Combine Harvester Factory in the 1980s is entirely different from John Deere's holding the majority of the shares of Deere-Jialian in the 1990s. This type of Chinese-foreign joint venture, in which the foreign company holds the majority of the shares, essentially creates a subsidiary company of the foreign multinational company. The subsidiary company is thus entitled to

adopt any new technology from the foreign headquarters, and the Chinese and foreign partners can explore the Chinese market in a joint effort. Furthermore, China has the advantages of low costs for labour and raw materials, so the characteristics of the two partners are complementary. The foreign partner can teach the Chinese partner advanced management through personal examples as well as verbal instruction, thereby creating a new corporate culture.

The successful joint venture between John Deere and Jialian is a very good example of Chinese-foreign co-operation in the farm machinery sector.

Foreign firms commonly have greater difficulties due to lack of understanding of the Chinese conditions. Joint ventures, in which the foreign party holds no more than 50% of the shares, have superior management and a higher rate of success.

This is a lesson that has been learned by foreign companies following the initial stage of the reform. With respect to international co-operation, China has invented a phrase called "exchange of market for technology", meaning that China is willing to open up part of the market, facilitating the entry of foreign firms in terms of policies, tax, and the relaxation of restrictions on share-holding by foreign firms, provided that China can obtain advanced technologies.

The Chinese government encourages foreign firms to supply farm machinery products which are urgently needed by the Chinese market and cannot be manufactured by the Chinese enterprises, e.g. 120-HP or larger wheeled tractors and combines.

2.3.3. China's farm machinery is not backward in all categories. China is not only self-sufficient in tractors under 120 HP, particularly small and medium-sized tractors, diesel engines and small combines, but also exports these machines to Europe, North America and especially to some countries in South America, Africa and Asia.

This is a good example of the division of labour in the globalisation of the world economy to exploit the competitive advantages of each nation. The production of small farm machinery in China is conducted on a very large and highly intensive scale, and thus offers remarkably competitive prices.

In 1997, China exported 36,618 small tractors and 380,000 small diesel engines to the world market. The unique features and superiority of China in the manufacture of medium-sized and small farm machinery have been proved reliable by the Chinese market over a long period of time.

Together with the introduction and absorption of large and extra-large advanced farm machinery from the developed countries, China will also promote the export of medium-sized and — especially — small farm machinery, and the strengthening of technical exchange in farm machinery with countries all over the world.

3. New trends of technological progress for China's farm machinery

As we enter the 21st century, China's agriculture is striding into a new historical stage. In the past two decades, the country's agriculture and rural economy have experienced rapid development. The overall supply of agricultural products and food has reached a relatively stable, sustainable balance with demand, in contrast with the deficit that existed previously.

Furthermore, there have been seasonal, structural and regional surpluses in the production of grain, horticultural and livestock products, and the market prices of grain, livestock and fishery products are lower than formerly. After China joins the WTO, it will face tremendous competitive pressure in the international market of farm products. To cope with this situation, China must do its best to increase agricultural productivity, reduce production costs and improve the quality and value-added technology for farm products. The Chinese government has confirmed that an overall improvement in the level of agricultural science and technology is essential for seizing opportunities and meeting challenges.

China is promoting a "new revolution in agricultural science and technology" programme. The "Compendium for the Development of Agricultural Science and Technology" for the period from 2001 to 2015 is being drafted, and measures for developing a hi-tech agricultural industry are being formulated.

The technology of farm machinery in China lags 15-20 years behind that of the developed countries. In the early twenty-first century, this gap is expected to be narrowed at a relatively rapid rate. Where possible, the strategy of skipping certain stages of development of the science and technology will be adopted in certain areas. China's farm machinery industry will be re-structured in scale and aggregation, expanding the co-operation with international agricultural syndicates.

With the support of information technology, the modernisation level of China's farm machinery will be raised in terms of research and development, manufacturing technology, enterprise management, quality control and after-sales service. The management of agricultural mechanisation in China will speed up the socialisation of the service system and develop towards the lease and contract systems.

A huge potential market will appear for advanced large and medium-sized farm machinery equipment.

Spurred by the domestic demand, China will develop a variety of innovative farm machinery and equipment, participate in the exchange on the international market, and make contributions to the agricultural modernisation of developing countries. Agricultural mechanisation in China will quickly absorb the results of the science and IT revolution, accelerating the development of new information- and knowledge-based farm machinery products. Starting this year, China has initiated trial and demonstration projects in "precision Farming" in certain areas.

Differential Global Positioning System (DGPS), Geographic Information System (GIS) and Remote Sensing (RS) will be applied to investigate site specific crop management and the technological renovation of farm machinery. International technical transfer and co-operation are being promoted in this field.

Based on the principle of equality and mutual benefit, China will strengthen the technical exchange and co-operation with its peers in the farm machinery industry around the world in order to assist the modernisation of China's agriculture, promote mutual understanding in the global farm machinery industry, and develop the world's farm machinery technology.

4. Conclusions

In the past 20 years, the “hot-spots” of demand for farm machinery in China have been small tractors, rural vehicles and combines. The demand for large and medium-sized complex farm power and implements as well as advanced post-harvest equipment has started to take shape. This provides a good opportunity for technology transfer by international farm machinery firms.

After joining the WTO, China will continue to maintain its competitiveness on the international market for small farm power. In addition, China will provide a broad scope for the development of technology markets to farm machinery groups from the developed countries with respect to large and medium-scale complex, advanced farm power and implements.

China already has in place a farm machinery industry of considerable scale, with good R&D capabilities. However, China is still economically a developing country. The demand for farm machinery in China will have to rely mainly on domestic R&D and production capabilities, even though the modern design, manufacture, technology and management of farm machinery in China lag far behind those of developed countries. China needs to strengthen its co-operation with the farm machinery syndicates of developed countries to promote the transfer of advanced technologies and explore a co-operation model appropriate to China's conditions. Simply selling farm machinery products to the Chinese market cannot be taken as a long-term strategy. In this connection, there have been successful experiences worth learning from.

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Table 1 - The development of agricultural mechanization from 1952 - 1978 in P.R. China

YEAR	1952	1957	1962	1965	1978
Total Farm Power (10^6 kW)	0.18	1.21	7.57	10.99	117.42
Large & Medium-sized Tractors (10^3 units)	1.307	14.67	54.94	72.6	557.36
Small-sized Tractors (10^3 units)	—	—	0.92	3.96	1373.0
Grain Combine Harvesters (10^3 units)	0.284	1.79	5.9	6.7	18.99

Table 2 - The development of agricultural mechanization during 1980 - 1998 in P.R. China

YEAR	1980	1986	1991	1993	1996	1998
Total Farm Power (10^6 kW)	147.4	228.1	294.2	315.6	385.5	440
Large & Medium-sized Tractors (10^3 units)	745	871	784	717	671	700

Small-sized Tractors (10^3 units)	1874	4528	7303	7826	9189	11060
Total Units of Grain Combine Harvesters (10^3 units)	27.05	30.95	43.55	56.27	96.38	181.78

Table 3 - The increase in agricultural mechanization level from 1978 in P.R. China

YEAR	1978	1980	1991	1993	1996	1998
Tillage %	40.9	42.4	52.45	54.5	57.81	62
Seeding %	8.9	10.9	16.47	18.13	21.38	24
Harvesting %	2.1	3.1	7.78	9.73	12.03	15

Table 4 - Annual output of large and medium-sized tractors in 1990's in P.R. China

YEAR	1990	1991	1992	1993	1994	1995	1996	1997	1998
10^3 Units	42.2	59.4	67.2	47.0	47.0	64.7	83.7	82.9	67.0

DISCUSSION

Derek SUTTON
Dear Colleagues before starting with Mr. Firodia's report, I ask you if you have some brief questions to pose, to the previous speakers.

Theodor FRIEDRICH
Prof. Wang, when you talk about socialisation of the contractor services do you refer to co-operative ownership or to private ownership of the machines?

WANG Maohua
The Chinese system has very fast changeovers; in fact now the service is also provided by individual farmers.

Gajendra SINGH
I think it would be useful if Prof Wang could explain the changeover in farm ownership, which is making all these dramatic changes in mechanisation.

WANG Maohua
In the Chinese system the Government has land ownership, while the management of the land and farms is by the individual farmer.

Derek H SUTTON
Prof. Wang, we heard in the Korean presentation that the average farm size is 1.2 hectares;

what is currently the average size in China?

WANG Maohua
In China the average farm size is about 0.5 hectares.

Transfer of technologies from developed to developing countries: experiences and results in Asia and the
Far East. The case of India.

by ***Abhay Firodia*** (India); ***Rolf Bacher*** and ***Karl Th. Renius*** (Germany)

1. **Tractor industry in India**

One of the most important changes, which have occurred in the south Asian sub continent, is the unprecedented growth of the agricultural economy. A look back at this century shows that generally the agricultural economy of India did not grow at all during the first half century from 1900 to 1950. The rate of growth of the agricultural economy between 1950 and 1970 was roughly 1% per annum.
The rate of growth of the agricultural economy rose in the 80s to about 2.5% per annum. During the decade of 90s, the agricultural economy of India has grown at a rate approximating 4.5% per annum. [1]. This has economic, social and political ramification.
The per capita income in the agriculture sec-tor also grew at a very high rate along with a moderate growth in the agricultural GDP (Gross Domestic Product) in India (**Fig. 1 and 2**).

The Indian agriculture scenario is handicapped with the following factors:

- small land holdings - while this varies from region to region, the average holding is about 2 hectares;
- relatively illiterate farmer, poor training, poor knowledge;
- poor infrastructure development in terms of road, storage facilities, transportation facilities, agricultural produce processing facilities (packaging, canning, rapid cooling etc.).

While during the socialist economy years from 1960 to 1990 the "Commanding Heights" of the industrial economy were possessed by the Government. On the other hand, the activity of agriculture in India has remained almost entirely in private hands. Producing industry such as steel, fertilisers, etc. the transportation industry such as railways, shipping, passenger road transportation, banking system, insurance system, was state owned.
The entire agricultural economy i.e. production of food grains, horticultural produce and cash crops such as oil seeds, sugar cane etc. remained entirely in private hands. The agricultural economy of India therefore was able to take advantage of changing technology in seeds, fertilisers and a liberalised, fanner friendly and supportive financial system, in spite of the handicaps mentioned above, such as small land holdings, illiterate farmer, and poor infrastructure.
Due to improved irrigation methods and systems, the dependence on monsoon rains de-creased. Three crops per year were possible in many parts of the country. Limited time for tillage/field preparation during and between crops made use of tractor power mandatory. Growing tractor population also changed the haulage scenario in the rural India. The bullock cart was replaced by the tractor.
On this background the tractor industry grew rapidly with the growth of the agricultural economy [2; 3; 4] (**Fig. 3**).
During 1960s Tractors were imported to India from renowned manufacturers the world over. During the 60s and 70s, local content was dramatically raised and the assemblers or im-porters graduated to tractor manufacturing ca-pability. production in units per year, rose to about 45000 in 1977, 93000 in 1987 and 250000 in 1997 [4].
The spectacular growth of the agricultural economy and the stupendous developments in

the “tractorisation” of India are only the first step of the “modernisation of the agricultural economy” of India. Due to the all round economic development, based on the vastly improved rate of GDP growth in India during the 1990s (about 5.5% instead of the earlier 2.5% so called Hindu rate of growth), the nature of the Indian economy, Indian society and particularly the Agricultural scene, will further change during the coming decades. Increasing urbanisation and growth of service sector of the economy will make labour costs in the agricultural sector to rise.

While tractorisation in the 1980s and 1990s has replaced the bullock with the tractor, further developments are expected to result in increasing use of farm mechanisation and advanced agricultural implements and equipment such as threshers, rotavators, spraying systems and such.

A review of the tractor technology in India indicated that the range of tractors made in India during the 1980s and the early 1990s was not friendly to accept the modern farm mechanisation devices.

The tractor industry in India is characterised by the following:

- large volume of production; tractor sale in the year 1998-99 was 265,000 units.
- low horse power range.

The most popular power range of tractors is 35 HP. This along with 25 and 45 HP defines the bulk of the market **(Fig. 4).**

The tractor producers concentrated on volume growth in a rapidly growing agricultural Economy. product innovation, technology, modernisation, efficiency improvement aspects were not the drivers for the development and growth of the tractor industry due to low level of external competition and importantly also due to acceptance by the farmers of the simple but robust construction and functioning of the available tractors. Neither competition from more advanced manufacturers nor a demanding market place with a knowledgeable customer was present, to dictate or insist upon change or improvement in tractor technology. Consequently, the average tractor sold in India bears the design characteristics of the 1950s with:

- 5/1 to 6/2 gearboxes with low comfort sliding gear shift;
- poor ergonomics;
- generally outdated hydraulics;
- low safety consideration in terms of brakes, ROPS (not mandated).

2. The Tempo OX concept

2.1. The conception of Tempo OX tractor

On the above background, need for a technologically superior tractor was felt and the Tempo OX Tractor was conceived [5]. The firm Bajaj Tempo Limited had long established connections with German entrepreneurs, engineers and industry having established in the past, technical collaborations starting in 1950's with Vidal Sohn, for 3 wheelers, with Zahnradfabrik Friedrichshafen (ZF) for transmissions. Today the company has collaboration with Diamler Chrysler who participates in the capital upto 16%.

Dr. Rolf Bacher and Mr. Abhay Firodia are second generation shareholders in Bajaj Tempo, their fathers having established this firm in 1958. A project was conceived to design, develop, manufacture and market a new family of tractors for India using technical inputs from renowned industry, University and consulting resources from Germany. The study phase started during end 1992.

The tractor concept as evolved not only sought to overcome limitations of the Indian tractor industry in terms of technology of gear boxes, outdated hydraulics and poor ergonomics, but while improving the technology of transmission and hydraulics, with an eye to the future, it was decided to design the tractor to ‘build in’ easy upgradation possibility to 4x4 drive, and adaptability to modern farm mechanisation devices such as threshers, etc. The concept was evolved to build a tractor, which is right for India in terms power output, but capable of efficiently utilising modern agricultural implements and methods.

Considerable strength on design, development, testing, production engineering and manufacturing is built-up by the firm Tempo during the last 4 decades. The technology level of this infrastructure is about the same as in high-developed countries.

Professor Renius, Head of the Department of Agricultural Machines at the University of Munich was consulted for:

- reviewing the concept of tractor suitable for India; market study and technical data was reviewed in details;
- finalising the selection of aggregates/systems;
- preparing the strategy for testing.

With the University, consultants and professionals involved from different countries, the tempo OX Tractor in that respect is truly a joint venture.

2.2. Customer expectations

While designing the OX tractor, following customer expectations were considered:

- improved power with high torque back up, for operating in different agro climatic conditions;
- efficient transmission and easy shifting of gears;
- higher capacity of hydraulics with sensitive response;
- good ergonomics;
- high reliability;
- less vibrations and noise;
- modern looks.

The above expectations were quantified to develop the OX tractor family concept. It was decided to start with the 45 HP tractor **(Fig. 5).**

3. Design and development of various aggregates. Technology transfer and major efforts [5]

3.1. Engine

The concept for OX family of tractors involved use of engines derived from the Mercedes OM 616 Diesel engine already industrialised by Tempo, to be converted to tractor application. i.e. from indirect to direct injection, further to be modified for the stiffness of block, crankshaft etc. and to be reengineered to deliver the necessary torque and horse power, suitable for tractor application. This work was carried out internally in Tempo with the active consultancy assistance from AVL List GmbH Graz, Austria. A modern tractor engine family was created to generate three engines, from the basic 2.4 Litre - 4 in line configuration:

- 45 HP from 2.6 Litre, 4 cylinders in line;
- 35 HP from 1.95 Litre, 3 cylinder in line;
- 60 HP from 3.25 Litre, 5 cylinder in line.

3.2. Transmission. Drive line

It was conceptualised to use a transmission design featuring many improvements such as syncromesh shifting, higher quality of gearing, driveline reliability [6]. The firm of ZF Passau, specialists in tractor transmission were contacted to provide design assistance and a family of axles suitable for tractors with horse power range of 25 HP to 65 HP are obtained under license.

Modifications were made to the transmission systems selected from M/s ZF Germany. The modifications were:

- ratios were altered to achieve desirable speeds;
- gears were strengthened for Indian usage load pattern;
- axle housing and axle shaft redesigned to suit “Wet Brake” configuration (**Figg. 6 and 7**).

The transmission for OX 45 contains 8 speeds forward, 4 speeds reverse and 2 shiftable speeds for the PTO.

3.3. Hydraulic powerlift

The ZF transmission was originally designed for using Bosch hydraulic valve with the ZF power lift block. Tempo decided to persevere with the excellent ZF hydraulic power lift and the Bosch control system. An agreement with M/s Bosch was realised to built up an adequate production system in India by Tempo. This was a very difficult procedure due to the required accuracy for hydraulic components, specifically valves.

3.4. Brake system

Wet Disc Brakes was an important features identified to be provided on the OX tractor. The safety and reliability was an important advance. Expectations of low pedal efforts and low noise were taken care of.

3.5. Front axle, weight distribution and stability

The required weight distribution was finalised considering the load with implement mounted on three-point linkage at the rear of the tractor. Full load and partial load conditions were taken into consideration.

Extensive finite element analysis (FEA) was done on these in the CAD environment in Tempo. In house designed front axle parts with different sizes and materials were evaluated to finalise.

3.6. Ergonomics

Seat layout was finalised in line with ISO requirements as shown in **Figure 8**. Bonnets and fenders were styled to be most modern and attractive (**Fig. 9**), a change from the 1950 styling of the Indian tractors. The CAD route on the comprehensive facilities did the design of tools for tool design & CNC manufacturing in Tempo.

4. Testing and analysis

Looking back, it was extremely helpful, to establish test facilities for the tractor components in a very early stage of the project. Elaborate design, analysis and testing plan as given below was followed:

- engine - FEA for structural parts, combustion studies for optimisation, performance and endurance tests and emission testing in laboratories of Tempo (**Fig. 10**). Finite element analysis of OX 45 front support bracket;
- transmission – the gear train, planetary gearing and differential gearing was evaluated for strength and life by detailed calculations. The transaxle was put on a closed loop axle test set up. The load cycle was finalised considering overloads based on field information. Statistical methods of forming load spectra helped to transfer fundamentals of West European transmission load analysis to specific Indian conditions;
- front axle and steering - FEA done to analyse for vertical load and drag load (**Fig. 11**);
- hydraulics - hydraulics were analysed in dynamic analysis software. Special test rigs were prepared for the pump endurance.
- Field-testing and certification was done after extensive in-house testing. Prototypes were submitted to Central Farm Machinery Training and Testing Institute (Budhni-M.P., India) for field-testing and certification.

5. Conclusions

Tempo started the training of service and sales staff during early stages of the project. These training programmes were most beneficial as more than 3000 OX Tractors have been produced after the series went into production in 1997. The customer acceptance and successful use of the new technology systems in the OX Tractor were thus successfully managed. Initially the production was limited and progress was slow due to:

entire design being new, need to establish in-house manufacturing capacity, as also to stabilise the supplier base;

the company Tempo was new to the business of tractor manufacture;

almost the entire tooling in terms of patterns, jigs, fixtures dies gauging equipment was designed and manufactured in house in Tempo's own tool room. A massive effort of designing, manufacturing, debugging and putting into production a large variety of components using variety of manufacturing equipment involved enormous engineering inputs, cost and time. The same activity, if it had totally been entrusted to a European firm with a comparable infrastructure, the time would have possibly reduced by a factor of 30% but the cost would have increased by a factor of five. The Indo-European collaborative efforts helped reduce the project costs and time significantly.

The restricted volume of the first production phase was however helpful to limit the risks of such a completely new introduced, complex product. Feedback from the market, was in those cases of outstanding value, where the farmers used the tractors intensively – some more than 1500 hs in the first year itself. [7]. The authors of this paper visited several of them personally and they found a high level of driver motivation because of no major technical problems but surprising good handling and performance.

The resultant is that the OX range of tractors is fully indigenous and therefore will be in a “low cost manufacturing situation” from the very inception of production. The OX range of tractors while sporting a list of new technology innovations is comparable in price to the competing/ established Indian tractors – among which several models are two generations older in concept, design and performance.

What has been created is truly a modern tractor, comparable in performance and characteristics to world market standards in its class. This has been achieved in a short time at a low investment. The introduction of the OX 45 has, along with liberalisation of the Indian economy and the declared plans of several global players to enter Indian market, stimulated desire on the part of the existing manufacturers also to improvise, innovate and generally modify their designs for the better.

Experience gained by the product designers including specialists in gear trains designers, hydraulic system designers, vehicle system designers, testing laboratories etc. in Tempo has been very considerable. The fall out of this effect is to create a large team of confident and experienced designers. A similar impact is felt on the development of process planning engineers, process tool designs, and on the fraternity of manufacturing engineers as a self-developed tractor project has proved a boost to the knowledge, experience and confidence.

The success of the OX 45 Tractor is gained from the synergy created between European technology houses and consultants such as University of Munich, Dr. Rolf Bacher, Prof. Renius, ZF Passau, AVL List GmbH, Bosch, etc. on one hand and the Indian engineers and manufacturers in the firm Bajaj Tempo, as also its suppliers, dealers etc. This tractor development project is distinguished by the fact that the co-operation between the Indian company and the European/German companies, consultants and University was based on professional and business considerations. The serious efforts on both sides ensure not only an interesting project but commercial success in future.

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Fig. 1 Per capita income in agriculture (Rs. per year)

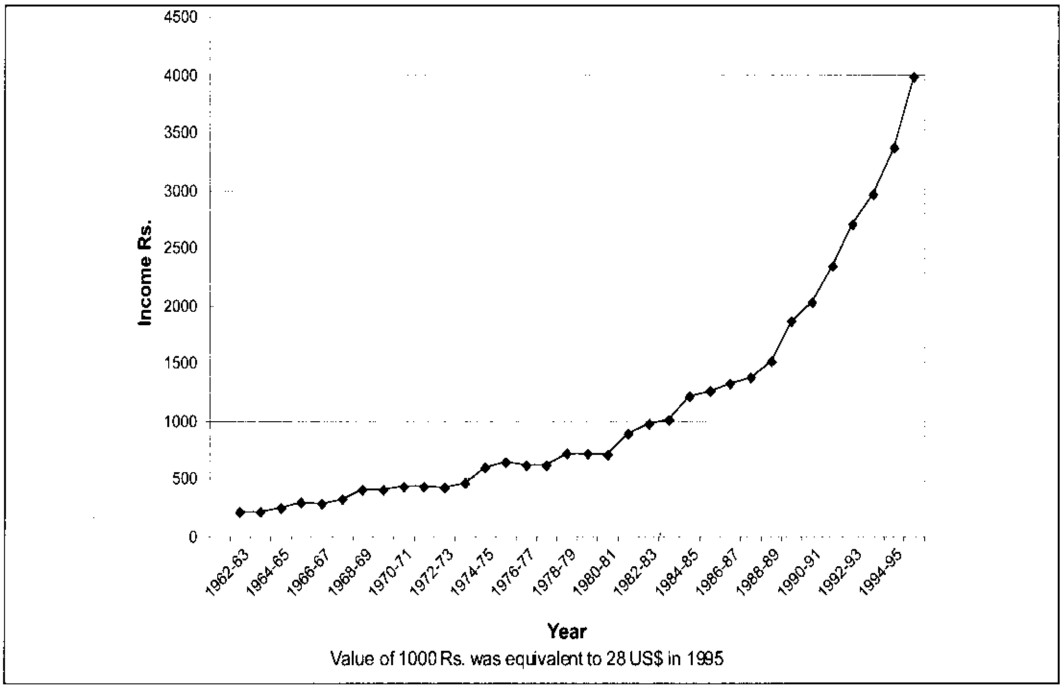


Fig. 2 - Agricultural GDP (rs. Crores)

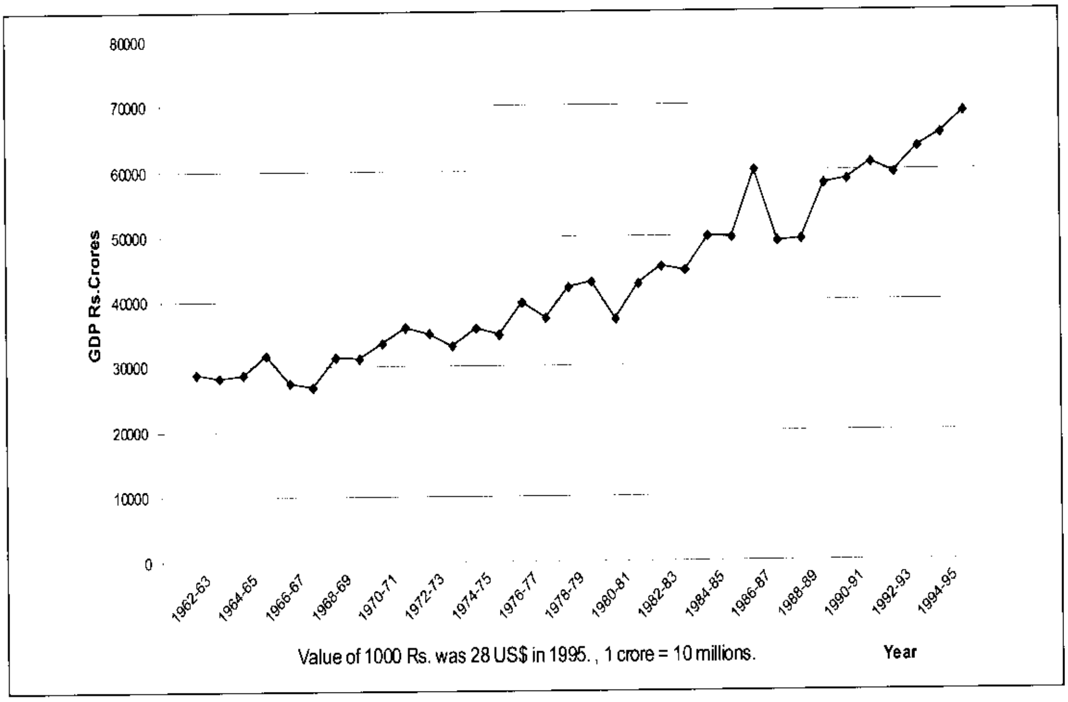


Fig. 3 - Tractor sale. Trend in last seven years

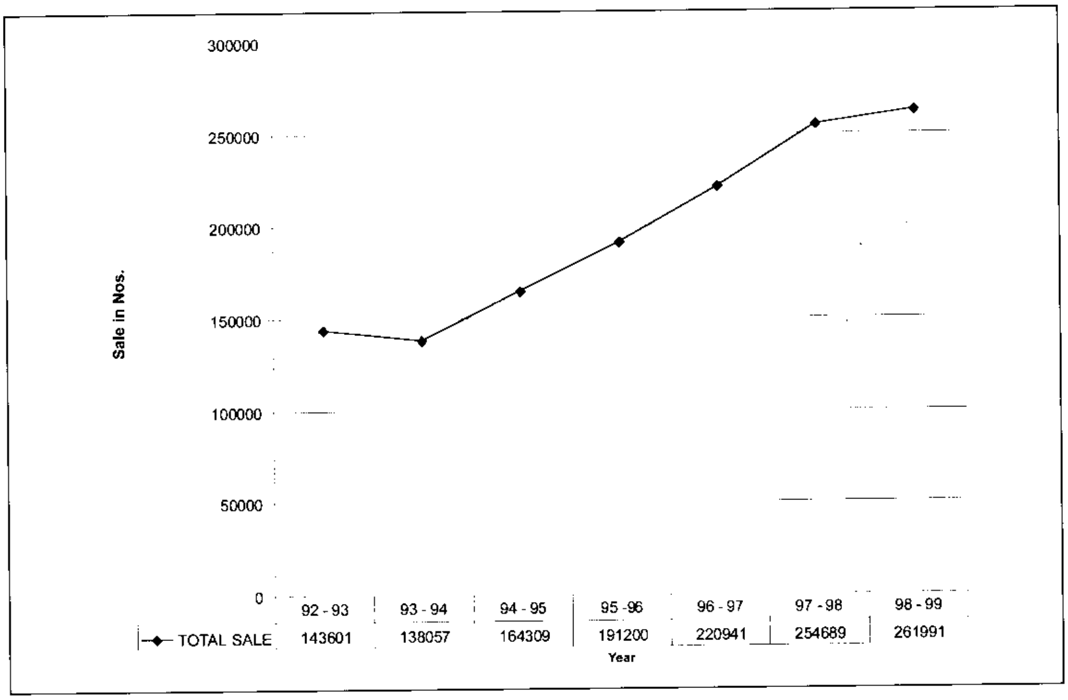


Fig. 4 - Segment wise tractor sale in numbers (1998-1999)

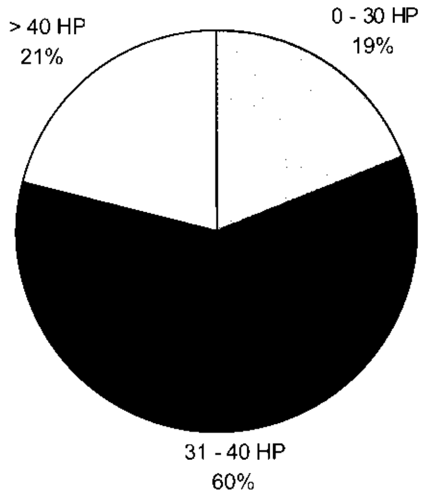


Fig. 5 - The OX 45 Tractor

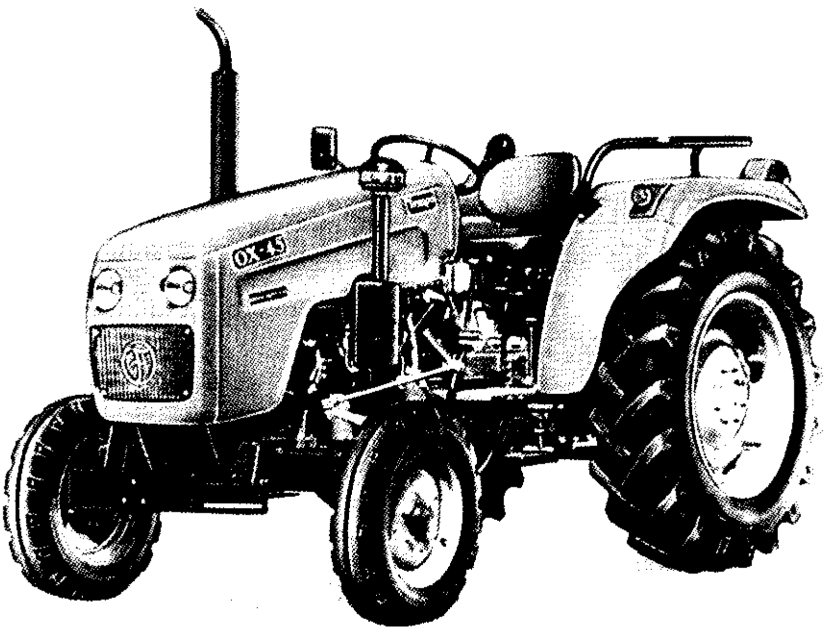


Fig. 6 - OX 45 transmission 12/4 with Syncromesh, 540/1000 PTO, Wet Brakes, planetary final drives and automatic three-point hitch control (Side view cross section)

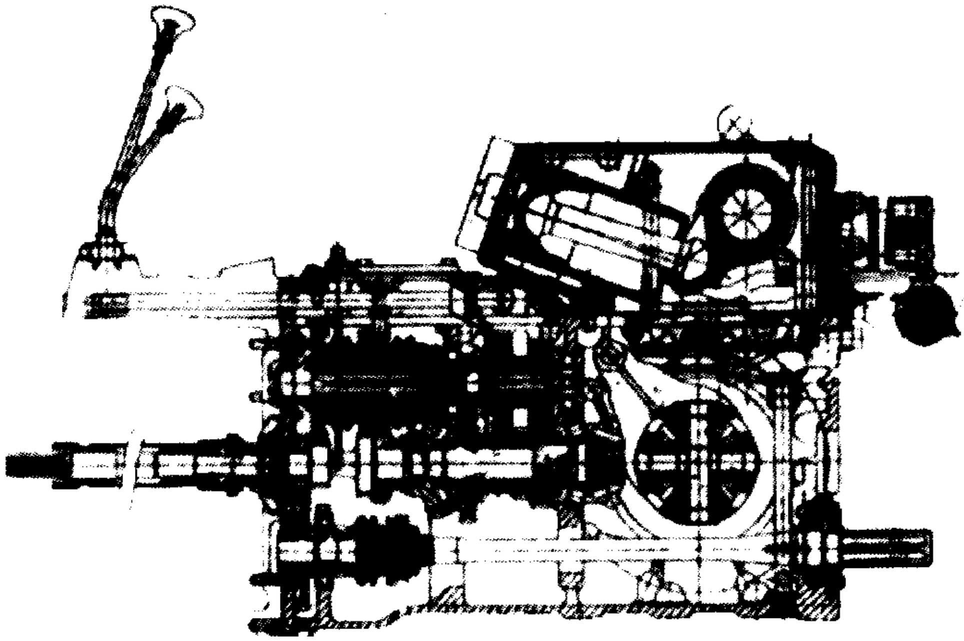


Fig. 7 - OX tractor TransAxle

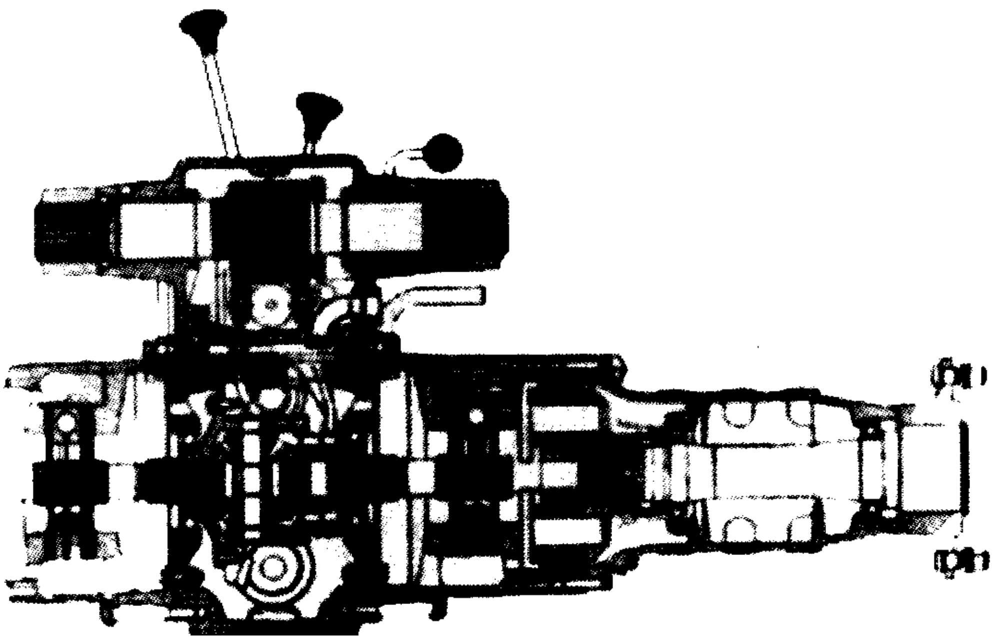


Fig. 8 - Tractor ergonomics

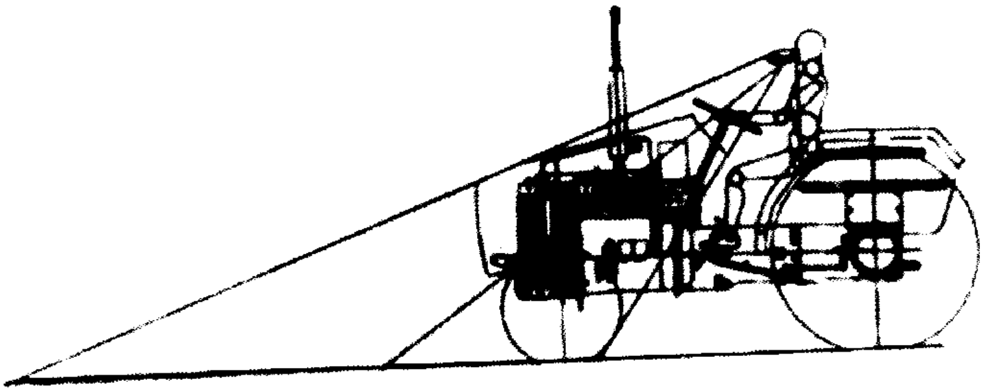


Fig. 9 - OX 45 bonnet and fenders

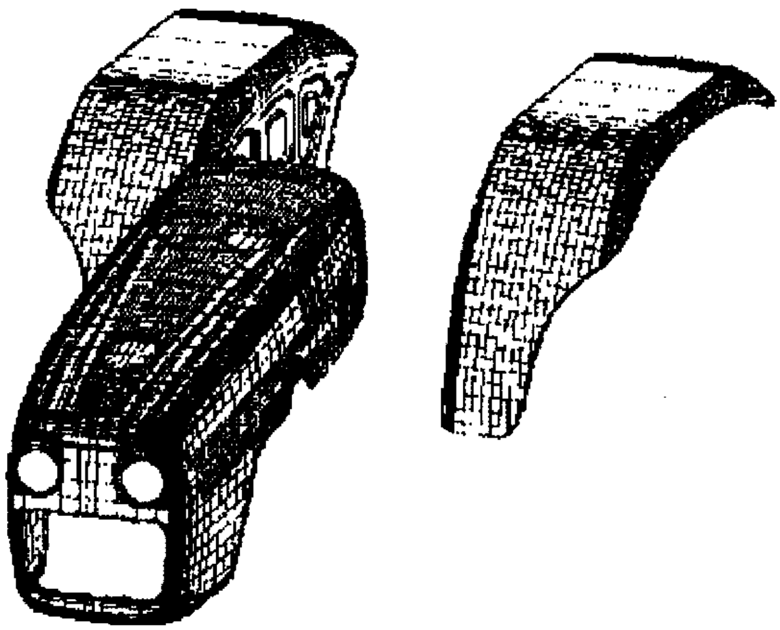


Fig. 10 - Finite element model of OX 45 front support bracket

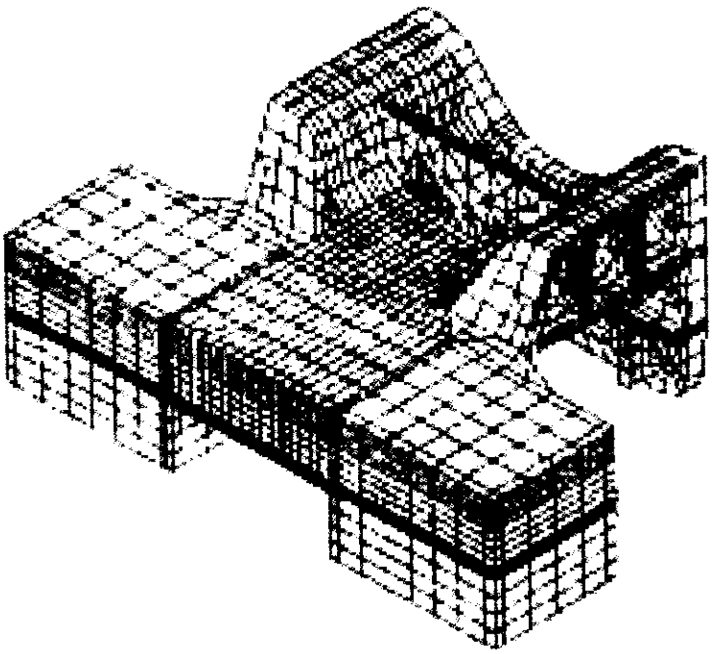
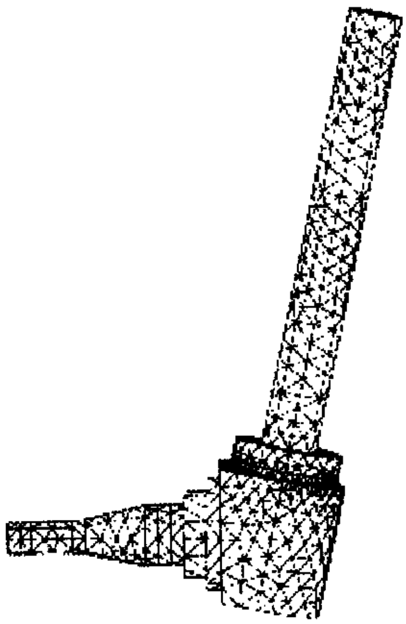


Fig. 11 - FEA of stub axle assembly



DISCUSSION

Derek H. SUTTON

We have had three super presentations and have a huge amount of information to discuss now. I just want to collect your thoughts and questions on the interventions. I was particularly amused by the realistic point of view of the psychology of selling, the shape of the tractor, the colour, the impression the customer has. All manufacturers, designers and the new agricultural engineers have to remember that there is somebody buying the thing at the end of the day, and that person must have his or her needs satisfied; so meeting the customer requirements it is extremely important. I think Mr. Firodia is a good example. He also attached another crucial aspect: the quality factor. It is perhaps relatively easy to get started in manufacturing with all the skills exiting from many of these countries by imported technology, but if you don't watch the quality, then you may not survive very long. I think that's another good lesson that we have clearly learnt in the experience of the tractor. Another one is that we must learn to maximise the benefit of that transfer of knowledge, in developing national capability. Mr. Firodia referred to the difficulties, or perhaps some shortcomings, in the Indian situation, in the communications between national centres and engineering designer development in agricultural engineering and perhaps industry; may be there is an area for improvement in something we could - as agricultural engineers - contribute to. I think not least the idea that if you've got a market you've got to understand the psychology of selling to people whose ideas could perhaps change; you must be fast and able to meet their rapidly-changing requirements, and adopt the dynamics of foreword thinking.

Yoav SARIG

We have heard a lot about the importation of tractors and combines, but I think the broad definition of technology transfer should not be restricted to tractors and combines alone. We should take into account the fact that we can offer far more sophisticated technologies in agriculture, irrigation equipment and harvesting and post-harvesting equipment. I fully agree with Dr. Sutton who previously remarked on high technology transfer has been set in time specific, but I would like to say that there is another factor that we have to consider and there is the philosophy of elaborating the machine. Let me give you an example. I had a discussion with a colleague of mine who gave me an American angle. The Americans are not interested in technology transfer, because they are not interested in allowing developing countries to become competitors in American growth. They are interested in selling commodities and machines, but not teaching the farmers in the less developed countries to do better than they do now. This philosophy should be taken into consideration, because technology transfer is not just selling a tractor, or selling up facilities for tractor manufacture in countries like India or China; it involves training and demonstration. The ultimate goal for the transfer of technology is to enable farmers in less developed countries to upgrade their state of living, to be able to produce more efficiently and to upgrade their production capabilities to the same level as their colleagues in other developing countries. China is an example of a country which has the highest rate of development in the world; they have their own development, so they should work also for their benefits, but at present this not being fulfilled. These are some of the issues I feel we ought to consider when we speak within the general framework of the Club of Bologna on the subject of technology transfer. Finally, I think that the countries we have considered are not necessarily the typical example of countries that require technology transfer; take Africa, for example, which is completely different; China and India are mega countries, with huge potentials and South Korea is a country with a high level of technology.

Giuseppe PELLIZZI

First of all I should like to know which are, in the different countries, the external or allied facilities for the development of technology transfer as Institutes for testing and for education, because we have heard something from Korea, but nothing from the other countries. One more question is about social conditions: do you have social barriers as well as institutional barriers? Mr. Firodia told us that farmers are not developed, so there is something for helping farmer development in order to help mechanisation. I have some additional questions for the different reports. As far as China is concerned, what is the reason for the production of such large tractors? I don't understand why, for instance, FIAT has produced a lot of tractors of about 150 kW, that are in contradiction with the size of the farm. May be this production is only for export, so in this case the developing countries could produce tractors or other agricultural machines at lower prices, in competition with the manufacturers from the developed countries. A few years ago, during a meeting concerning the problem of the economic condition for the development, we invited an economist from United States who expressed the idea that, in the near future, the developed countries will be forced to give developing ones the production of agricultural machines. The prospects of technological development are not in favour of developed countries, but in favour of developing countries. One more question to Mr. Firodia: I have known the Budhni Institute many years ago, but I should like to know what the relationship is between the manufacturers and I.C.A.R. (the Indian Council of Agricultural Research), which has a section specialised in Agricultural Engineering. Are the manufacturers interested in contacts with it or not? When I was in India last year, for instance, people from the Institute told me they needed to set up joint ventures for implement production such as for fruit harvesters, tomato and garlic harvesters, and so on. Do these ideas come from the Institute or are these ideas also discussed with manufacturers and industry? This seems to me a very important point to clarify.

Abhay FIRODIA

Today the Budhni Testing Institute is interested in the tank of testing and certifying all agricultural equipment before it can be produced and marketed. The Indian Council for Agricultural Research may have an influence on the Institute, but there are three separate bodies connected with the agricultural scenario in India. One is the Tractor Manufacturers' Association, an industrial association which examines different objectives. The Budhni Testing Institute, which is under the Ministry of Agriculture, has its own motivations. Finally there is the I.C.A.R., which has to look ahead to what should happen on the Indian agricultural scenario. I'm sorry to say that there is no real collaboration on a day-to-day basis, because there are no bases. There is no real motivation to work together to work out a comprehensive plan, to examine farm mechanisation and implements, to examine processes or the preservation of food. Dr. Kim this morning said that drivers are not using tractors as in Korea. The point is that in India there is a great danger: if you should use a combine harvester and take the green, but it rains later that week, you destroy the whole crop, because the storage facilities have not been created. The problem is that you cannot create these facilities unless they are economically motivated. The other question was about taxes for joint-ventures. You need tax relief or some kind of economic motivation to incorporate all these factors - the development of farm mechanisation, the development of storage facilities, etc. The tractor has succeeded in India because it is more economical than the bull and the farmer can manage three crops if he uses it. I'll give you a small example: in India, in the last five years, there has been a telecommunication revolution: now in every village you can find a public telephone to call every country in the world. Twenty years ago when a farmer wanted to take his products to market he had to cut, remove and load them on the bull cart in the evening, so that from five o'clock to *nine o'clock he was loading his bull cart. Early in the morning at four o 'clock he would set off, arriving at the market at nine o'clock. Then he would look for his broker: "I've brought five quintals of potatoes, how rich can I get? ", and the broker would only say: "You have come on a bad day, today trade is very bad". Now with telecommunications the farmer does not have to transport his crop beforehand. He just has to ring his broker at*

five in the morning to ask:" How is the market today?". He will accept only when he likes the rate and then he will cut and put the cabbage on the cart and in half an hour by nine o'clock again he will be at the market. The key is economic incentive, when the farmer will understand that he will make a better profit if he uses mechanisation.

Gajendra SINGH

The links between the various bodies are really very poor because of Indian bureaucracy. We work together in a forum, but cooperation is more limited to discussions. In principle there is agreement, but there are things that go slowly in the Government set-up, for example, the Ministry in charge has to accept and then notify and so on. We are growing and changing; agricultural growth rates are higher in India compared to other pans of the world.

WANG Maohua

In China since the beginning of the system a testing system has been created which refers to the OECD international standards for all the exported and imported tractors. Besides that, each province has its own farm machinery testing centre, based on local conditions, and since the 1950s an educational system has been in operation in high school.

Keyong Uk KIM

In Korea, thanks to a National Institute, every machine can be tested under the guidance of the Government. About training: a program for manufacturers - 3 or 4 days long - is provided by companies and Institutes, while a week program for training the technicians - 7 or 10 days long - consists of an educational study period at the National agencies.

Giuseppe PELLIZZI

I would like to know also from the three speakers if the system of the after-sale services is subsidised by the Government or if it is a direct responsibility of the manufacturer?

Chang Joo CHUNG
KOREA

In Korea we have a very good government program for the testing and inspection of farm machinery and also for the training of farmers and specialists. As regards social condition, the government supports a joint use pro-gram paying a part of the machinery price. One may add that we have many different tractor models and we always have problems in acquiring spare pans. Our aim in the future is to solve this problem.

Abhay FIRODIA

The current situation in India is very similar to that of Korea during the vaulting period It was customary in India for the farmer to depend on the dealer during the warranty period; later on a great number of specialised mechanics developed In every village we have one or two mechanics now, someone specialised in one tractor, someone in an-other, and the farmer usually turns to this organisation which is not controlled by the dealer and which normally charges high prices. One peculiar aspect is that spare pans are sold not just by the equipment manufacturers, but also by an illegal market. They look the same as the original, but the cost is very low and so is the quality. This industry probably has the larger market share if you compare it to the original industry, but in the end it does a lot of damage. The quality aspect is a compromise in the fact that there is a very high level of taxation on spare parts normally produced, whereas in the illegal *market the suppliers are often able to evade tax and they have low prices.*

WANG Maohua

The industry experience in developing countries can be very helpful in promoting development, as in the instance of John Deere and New Holland; their products, largest skill tractors and combines, are widely used in the north-eastern part of my country. The boss of this industry has created a representative office closed to the USA, while in another region - more convenient for transportation - he has created machine storage facilities. For local industry it is very useful to look at the experiences of developed countries.

Bill STOUT
USA

I've found the presentations very interesting, but 1 want to play the devil's advocate. I've been working around mechanisation in the developing countries for nearly forty years and I've often heard people saying: "Give me a simple product" particularly when working with farmers with very a low degree of education or background." Is that statement wrong or is the technologically superior product that you describe the correct way to go? I just wonder how far we should go in sophisticated technology for this low level of education.

Abhay FIRODIA

I think there are stages of technological development that have to be clearly identified. A transition occurred in the 80s when a lot of electric and electronic devices as well as sophisticated systems were introduced for improved operator comfort and cab conditions. When we look at developing countries, we do not want to reach their stage of sophistication where there is a cab with air conditioning and TV; this will not work because it is too expensive for us. Mechanisation and improvement on mechanisation have to be restricted to the actual power requirement for that particular machine. In all developing countries when one wants a machine it is necessary to say: "This is my horse power range, this is the level of sophistication, I need you to build it". You must be selective in what you take and not blindly imitate what the industry leaders in the USA such as John Deere and Case, may be doing. What they do is for the western market, not for the developing market.

Yoav SARIG

I don 't think Prof Stout's comment is true for every country; it may be true for Africa, but my experience is that in China the farmers, first of all, are well educated, they I would just like to make a comment on that receive a very wide range of training. So I don't think that what was true in the past – "give me the most simple equipment" - should be applied to China, I don't know about Korea, but it 's probably the same.

Bassam A. SNOBAR
Jordan

When we talk about the transfer of technology we have to talk about the level of technology in connection with use. India, as well as China, is a developing country, where we are going replace the use of animals with that of tractors. In this transitional period what kind of training do you have to give to the farmer? How can he be convinced to change? Why is he going to use it? The case of communication by telephone in the village constitutes a perfect use of ready technology; its changes on the farmer's life really are linked to the transfer of technology, but they still need to be defined Can we measure technology transfer by simple calculations, figures, or numbers? What did you do with bullet production? I know that in China the number of animals in use is about 20 million, but what will happen to these animals? As for actual sophistication, when we talk about the transfer of technologies in the sense of farm machinery, we have to take the technologies *available in the developed countries and transfer just a simple part. Then the country itself has to develop the technology.*

Theodor FRIEDRICH

I was very impressed by the presentation on sophistication; however, I think you still have limited ergonomic and contemporary components compared to what the market would actually pay for. For example, my tractor is lacking the one thing which I would look for on any contemporary tractor - bar protection. How could this be overcome?

Abhay FIRODIA

I fully agree with you. I think this is where the Government has to put its funds. The day that the Government does it, every manufacturer will fit every tractor with R.O.P.S. These are things that must be provided, but it is not a question of technology, but of regulations.

El Hassan BOURARACH

We see that the number of tractors sold in India is very high. In Africa the market is smaller, and for that reason it is better to concentrate efforts on training rather than on simplicity, which will cost money.

Derek H. SUTTON

Might I ask Dr. Fischer if you have any comments on your life-time experience on this sort of aspect?

Lothar FISCHER

Yes, I've had some experience. In the late '70s I had a contract with China to transfer tractor and combine knowledge. Experience was gained on both sides. We had our experiences, and not only with John Deere. In answer to Dr. Kim's remark, I would say that you gain experience when you see that your products are copied and afterwards priced down into your own market. As managers of western companies, we have to represent our old interests and to look at the question from the business point of view. As far as the violation of contracts is concerned, if you have one in some countries it is not easy to find a judge who represents your interests. I fully agree with Prof. Kim: what we should do in the future is to define fair corporations, or joint-ventures, and the developing companies have to agree that the developed companies want to have a say in controlling what goes on.

Malcolm McKAY

Some issues have been covered, but I think others must be commented on. It seems to me that most of the agricultural and related engineers are very interested in machine functionality and technology transfer. From each paper this morning we have had a very significant concentration, a list of input to technology transfer, from the manufacturing sense to the desire to localise production and components in that country.

Hugo CETRANGOLO

My comment concerns the informal transfer of technology. My question to M.r Firodia is that if I'm conducting negotiations to reach an agreement in technological and commercial issues between a company like yours and a huge high-tech company, for example Bosch, what are the difficulties involved? What is your experience in this field?

Abhay FIRODIA

These companies have great experience which is favourable for the transfer of technology to our company, or country. Their latest products have had an impact on different aspects of technology; for instance a current family of Bosch valves is more expensive. If you look at the fact that the previous one was about DM 150 and the new one DM 350, then the new valve is still 1% of the price of a current tractor compared to the rest of the world, which is 0.5 % of the price of the all tractors. So from their point of view the valve to pro *duce is the current one. From our point of view this small valve is relevant because we are looking at it in relation to its use; they were not hesitant in passing on that technology because they were not involved in that latest technology. From our point of view their latest technology was irrelevant to us. It was not just a question of being expensive.*

Darrin DROLLINGER

USA

I have a very brief question for Mr Firodia. After all the work you mentioned 60 key employees or skilled workers. What about conducting a transfer of technology in exchange for property? Is it an issue that should or could be addressed?

Abhay FIRODIA

It is an important issue that should be addressed. I think India has ability to produce a lot of skilled workers at a very low cost. One has to recognise that any manufacturer who takes the first step in any market in developing new technology, processes or products, also has a natural moral obligation to train people.

Antonio PAGANI

Italy

I would like to comment on the three presentations made. In all three the topic of the transfer of technology was considered at the top level, in which joint-venture is a key word, and a sometimes misused word, that includes a lot of different types of arrangement. It is not by chance that the examples made during the presentations referred to some of the most well-known manufacturers of agricultural machinery in the world. We all know that in the industrialised countries, particularly in Europe, there are thousands of medium-sized manufacturers, and sometimes small manufacturers, that are depositories of very advanced technologies which, in most cases, are useful to developing countries, too. These medium-sized manufacturers are a little reluctant to enter into joint-ventures as such because they are not equipped for it, they are not mentally prepared. What they require is a more flexible sort of arrangement, sometimes tailor-made for a specific arrangement, which requires more commitment on the part of both the owner of the technology and the recipient. However, I have not heard anything about this level of technology transfer or the attitude of countries wanting this level of technology transfer, not just the top one.

Jorge A. HILBERT

I wanted to point out that there has been an increasing phenomenon in the past few present years – that of companies merging. In a country like Argentina it's very difficult to compete with these big companies, primarily because they have cheap access to capitals and credits, so some industries are closing. I think that local farms should be subsidised by economic and educational support, in order to be able to adapt and compete with the world as a whole. In our teams in South America we compare two worlds within the same country: we have highly-developed farms using high-tech, intensive capital, but we also have also the lower scale of the farming community which is going down, becoming poorer and poorer. This particular situation is quite general throughout South and Central America .

Yoav SARIG

I just want to comment on the medium-sized company from my experience in China. All I can say is that it is more difficult for medium- and small-sized companies to enter into collaborations or joint-ventures in China. The possibility exists - we have several examples of companies who have managed to do this, and they are doing it well - but of course it is necessary to have a unique product and unique quality.

Arturo LARA LOPEZ

In all three cases there is an important thing to notice: in those countries there are already well-supported engineering groups, which can significantly improve communications and contribute to technological transfer. For that reason in all developing countries it is important to train the engineers, to support joint-ventures and also to train design engineers for possible transfer to local conditions.

Uri M. PEIPER

This morning we heard three papers from completely different three countries in terms of structure and outlook on life. The transfer of technology has to be tailor-made; not every country can benefit from the knowledge of another country. So we need to develop technology for the transfer of technology: this will really would be a benefit for all countries.

Yoshisuke KISHIDA

Today the three speakers talked of their experiences. What I can say about the transfer of technology is that we don't have to generalise methods: the case of Africa is different to that of Korea. I propose, in future, that the Club of Bologna should discuss further on other specific case areas. In Japan we have many re-quests from developing countries for the transfer of technology specially developed by small skilled manufacturers, but in many cases small manufacturers are also design engineers, marketing managers and production managers and they have no time for this.

Giuseppe PELLIZZI

I think that the problem mentioned by Mr. Kishida and Dr. Pagani is very important and I want to refer to an experience I had concerning India. I found that in India if it is true that there are no more buffalo for agriculture, there are no designers for tractors. I've seen many research institutes produce small implements for animal draft without any connection with the bigger manufacturers. So I cannot understand why it is not possible to try to transfer technology from one developed country to another, with reference to smaller companies.

Gajendra SINGH

I agree with Prof Pellizzi. In India we don't have tractorisation; it means we don't have enough mechanisation. Having said that, the tractor has replaced bullocks for many activities - including agricultural field operations - and economic justification of tractor has become more important for agricultural and non-agricultural activities alike. I made a presentation in Dr. Sutton's meeting organised in London, where we said that the percentage of tractors used on farms was 31%; with 69% used outside the farm. I think the medium- and small-sized manufacturers play a big part here in developing partnerships and collaborations. In India equipment for animals is very different. I don't think that tractor-drawn equipment could be as multi-purpose as the animal-drawn type. In India the industrial aim is to develop appropriate equipment for tractors so that tractor use can be improved, because in the very near future the transport infrastructure and the roads will be improved. Nowadays we make tractors just for transport and it limits the use within the different agricultural sectors. We make tractors for tillage and transport alone. India is number one in the transport sector: 1 billion people confirm this statistic, just like China, whose size is confirmed by the number of its inhabitants.

Giuseppe PELLIZZI

Does your Government support the transfer of technology as far as equipment is concerned?

Gajendra SINGH

Indian Government in principle supports it, but procedures are too slow: nobody wants to take responsibility for decisions.

Irenilza DE ALENCAR NÄÄS

Brazil

I'm trying to reflect a little on the subject in relation to the Brazilian situation. It is hard for me to try to transfer this knowledge into my country, because each situation is very different from a country to an other. Our case is quite different from all the other points of view; we have very poor farmers and very rich farmers. One person may be using very low technology while his neighbour is using the same degree of precision farming found in developed countries. Probably the main issue we have here is the transfer of technology within the country and how to do that in the best way. It is a challenge, particularly because we don't just need to improve cropping by improving mechanisation; there are also the problems of how to store, retail and transport crops. And how can animal production sites be improved? The main challenge, at least for us, is how to change all that and transfer the entire technology package within the country. So that's the biggest problem in Brazil: the small farmers. We have now a strong social movement that is going to have a new co-operation between the small farmers. The circle of technology transfer is not static; it is dynamic, and involves a lot of the sector.

Oleg MARCHENKO

I would like to point out another side to this problem. Of course, the transfer of technology and machinery is a complex problem. You can buy some machines and use them in different countries, with different technologies and efficiency. I had 7 years' experience in these activities because I had to check for investments, technique and technology for Russian agriculture and also for the activities of USA-Russia economical, scientific and technical co-operation. It is necessary to co-ordinate this problem, taking into account the fact that we have some foreign companies which try to sell new machinery, to established joint-ventures without any testing or certification, creating a crucial situation. For big countries like Russia, China and India as well, there are so many different climatic conditions, populations, field sizes, levels of industrial development, and so on. When we try to transfer technology to a certain region, we need to test technology, to determine demand, to estimate which is the best place for joint-venture to cover demand. This entire situation shows us that we need coordination on a federal Government level and also on a regional level. It seems to me that this problem is very important. What will we have in future? Unification: if we bought a different kind of machinery we would have problems with service. We create special farms of international investments and insurance investments for foreign countries, so it is just the beginning, in order to attract foreign investments for new technology and new techniques which are attractive to the Russian Agricultural Federation.

Chak CHAKKAPAK

Thailand

One of the most important things is the cost of machinery. Here in Europe, or in America, every year there is more sophisticated machinery, but in developing countries, for the fact that farmers have to pay more for the same machine, the market is becoming more and more difficult in terms of developing machinery.

Jürgen HELLEBRAND

I would like to stress that this financial aspect, is important for the transfer of technology. The situation inside the countries is different because of the political and economic conditions and therefore the technology transfer always depends on the country in question. The situation is not a simply a transfer from a developed country to developing countries, but maybe a transfer from one developed country to another, as we have in Europe. I think here we can recognise that the conditions within the countries influence the transfer of technology. This is one question that should be solved in the future and I would like to know what the situation is in South Korea in connection to this.

Keyong Uk KIM

I think that utilising the new technology is an advantage for the farmers themselves, but they want to go back to simple machines, like the ones they used several years ago, because they don't have any subsidy. Those in industry just want to develop new models, putting highly sophisticated technology into the machines in order to try to sell them at a higher price.

Francis SEVILA

I'm always annoyed, dear colleagues, to have the same discussions only through analyses of what is happening between companies, or institutes. My opinion is that the main transfer of technology from advanced technology to industry is via education. I think that to help the educational process is the first priority, and this can also help in the transfer of technology. We have heard Prof. Singh promoting his position to have European students in his Institute to study there and we have some developing country students coming to our University. We should not forget this aspect when discussing the transfer of technology.

Evandro MANTOVANI

Brazil

I have a comment on the transfer of technology. I come from a National Research Organisation, with 39 research centres all over the country. We develop technology for the tropical regions, in all the aspects of crop production systems; technology mostly needs to take into consideration the crop system. Many countries have their own technologies and crop production systems; the question is: can technology be used to a greater effect than it's being used now?

El Hassan BOURARACH

I just want to point out that in developing countries we have to speak about rural mechanisation, rather then agricultural mechanisation, because tractors and all implements are more used for rural developments, like transport. Secondly I want to come back to the idea of Prof. Pellizzi: what will be the distribution of roles in globalisation ? Will mechanisation production or low technology production shift to the developing countries? I think both types of country will benefit from this; we need somebody who can produce cheaper, with good quality and technical assistance and the case of India was a very good illustration of this.

Yoshisuke KISHIDA

I'd like to draw attention to the changes in trade policy. Dr. Kim talked about history of the mechanisation in Korea, focusing heavily on the considerable transfer of technology from Japanese companies. I believe that the reason why Japanese companies transfer their technology is because the Korean Government has a strong policy to protect its own agricultural machinery industry. Otherwise I believe Japanese agricultural machinery companies must directly export their products; in that case the transfer of technology is not through Government production, but through the products. Now the Korean Government – along with a few others - has changed its trade policy. In the 20th century maybe the technological transfer aspect should be changed, making a system not only to introduce technology transfer for production, but to export products directly.

Jorge A. HILBERT

I want to say that we need to separate and qualify technology in certain terms: energy efficiency, environmental care, life quality, human factors and so on. Technology evolves according to the conditions you give it to evolve; for example in Europe you have high prices for farm products, so you have high cost technology.

Gajendra SINGH

I'd like to emphasise that when you are transferring technology on a specify product, the scenario is very different. I'd like to support the case put by Prof. Sevilla, that the best way to transfer technology is to train people in the advanced technologies, and then people living in the real situations will judge what is the best for their country. What we see in India in the agricultural revolution depends on US support in bringing a large number of people to do higher education in the USA. What they did was expose people to the various technologies so that these scientists could analyse and choose the most useful ones for their particular circumstances. As Prof. Pellizzi has always said, the movement of young people to different countries, the exchange of people is very important; for that reason I tell you again that the European Union has very kindly donated a very large amount of money to allow people to go to Asia.

Derek SUTTON

A very useful reminder at the end of a very technical session, not necessarily about technology, because technology is for people to use. At the end of the list there is one important person, who has asked me to speak, but I have asked him to increase his intervention a little, to help me in summarising. So, - a good friend – Prof Renius, will make a few comments to conclude the session.

Karl Th. RENIUS

The cost of tractor production influences economic costs, but the cost of tractor production for example in India is a 1/3 compared to that of Europe, so it makes a lot of sense to pro-duce there. If we analyse the question of competition, one day Indian manufacturers may compete with German ones. As the technology level and tractor power level are becoming wider and wider, may be a tractor power popular in India is completely out in Europe, in North America, Canada, Australia, so I don't see problems regarding this competition. What I see are great changes for countries like India, to deliver tractors on low price bases to other developing countries like Africa. For Africans the problem is not to have engineers; their first problem is the civil war. Another point is: what is the right technology level for the right economic solution? We should face the realistic market needs and adjust technology to these. To find existing solutions is not very easy, but it is very important in my opinion. Then there is education, which has been stressed two or three times, because it is the first factor. Regarding the European approach, mentioned by Prof. Singh, I'm not completely convinced that it is the right direction. I think it's very difficult to find a guy, even if you give him money enough to send him to Asia, to study there. You mentioned also the opposite direction: so I invite everyone to come to Munich University, which is one of the best and costs nothing. Finally, I agree with Derek. Sutton: the friend-ship between personalities is the first influence in business and my feeling is that we do good things in this Club, because we are friends and many good things can be developed by this Club.

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