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WORKSHOP ON
CO-OPERATION AMONG DEVELOPING COUNTRIES ON
PLASTIC IN AGRICULTURE IN ARID AND SEMI-ARID ZONES

12-16 February 1990
ALGIERS - ALGERIA

UC/RAB/88/155

WATER MANAGEMENT WITH PLASTICULTURE

prepared by

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1. **Plastics in agriculture - Water management - an appropriate approach for developing countries in arid and semi-arid areas.**

2. **Lining, Water Canals, Water Courses with plastic membrane to reduce water loss & seepage. Using plastic membrane underlay in plant beds in highly porous soils.**

3. **Rain water harvesting with Plastics - Lining reservoirs with plastic membrane underlay - Using grid connected buried PVC pipe network connecting borewells for integrated irrigation.**

4. **Optimising crop water use by adopting drip or sprinkler irrigation - Electro osmotic irrigation using photovoltaic array - Using evaporation & condensation of water from saline sources for agriculture.**

1. Plastics in Agriculture - Water management - an appropriate approach for developing countries in Arid & Semi-arid areas.

1.1.: Introduction : As an engineer by University qualification and being actively engaged in the plastics conversion industry for over 30 years and exposed to agricultural applications of plastics for over two decades and coming from a developing country I have volumes of information to communicate to a Workshop such as this. From the extensive exposure I have had all over the developing world, the diverse problems that we face in achieving better economic conditions for our poor farmers has attracted my constant attention and I hope to cover within the four presentations that I have been entrusted with, as wide a spectrum as manageable. In this first presentation I would like to highlight aspects connected with Plasticulture which are more or less applicable to all developing countries which are inhibiting faster acceptance of these technologies, most of which can truly bring about a complete change to agriculture, on which around 80% of population in our countries depend.

1.2.1 Plastics : Although some of the developing countries have developed basic commodity plastic raw material facilities, there would be quite a few who cannot establish such highly capital intensive industry in the foreseable future. Bulk of agricultural applications are from Low Density & High Density Polyethylene P.V.C, Polypropylene and relatively small quantities of specialised "Engineering Plastics". In all delveloping countries, the prices of all plastic raw materials are found to be high on account of the relatively small scale of production and even more commonly on account of fiscal levies by the local governments. The conditions that prevail in India, for instance, would tipify the nature of this problem elsewhere in varying degrees. We indigenously produce as on date around 1,00,000 tons of LDPE, 80,000 tons of PVC, 50,000 tons of HDPE, 30,000 tons of Polypropylene besides polystyrene, abs etc. We have plans for massive additional capacities, some of which are nearly getting ready for production in the coming years. The present prices of raw materials are above US $2 per Kg whereas the world prices are well under US $1 per Kg. LDPE & HDPE are as low as US $0.75 per Kg. While such high local prices does not seriously affect the industry as a whole, agricultural applications get seriously affected as they become far from "affordable" by the poor farmers. The duties on imports from the much cheaper international markets makes this import not so attractive and it, at best, serves to supplement shortages. The imported raw material, after payment of duty, lands at somewhat higher than the price of local material. We set up a National Committee for plastics in Agriculture and this committee made a series of recommendations to the Govt. as a result of which some remedial measures are slowly being introduced to propagate Plasticulture technologies. First, to compensate for the high levels of Excise/Import duties on raw materials, a scheme of subsidy for agricultural applications have been introduced. Although this subsidy is quite inadequate at present, the acceptance of the need for this measure is itself quite promising. Secondly, the National Bank for Agriculture & Rural Development underwrite Plasticulture advances made by the network of nationalised banks in the country and when this is done, the interest rates for the farmers on such advances comes down from around 16.5% to around 11-12 % . These two measures have helped propagate Drip and Sprinkler Irrigation in a spectacular way over the last couple of years. Where a developing country does not have its own Petrochemical Industry, it is important to adopt this subsidy/easy credit schemes to propagate Plasticulture applications. The most important step is to set up plastic conversion industries and save foreign exchange. It would be economical to import plastic raw material and not the finished products. In India, the Govt. levies over 300% duty on any finished plastic products. Such punitive duties only will help indigenous capabilities to develop fast.

1.2.2. Agriculture : In most developing countries, agricultural holdings are small and therefore the technologies, even in Plasticulture as adopted by the advanced countries cannot be transfered verbatim. A considerable adoptation would be necessary to make these basic principles of Plasticulture reach the poor farmer with small holdings. Quite often, there would be no electrical grid power available and even when this is available to a few lucky farmers, it would be restricted to a few hours in the day. Access to trained service facility could be lacking and illiteracy prevents your handing out printed "instructions". Yet, the difference that the useful Plasticulture technologies could make to the economic conditions of such poor farmers in all our developing countries warrants all efforts on our part to implement these with utmost speed. Automation is most irrelevant. Farm labour is inexpensive and plentifully available.

1.2.3. Water Management : Water is a vital part of man's enviroment and the extent to which it is abundant or scarce, clean or polluted, benificial or destructive determines, to a very large extent the quality of life on this planet. The total water content of the planet neither grows nor diminishes & is believed to be precisely same now as it was even three billion years ago. While this situation looks so optimistic in a situation where many other resources like oil are fast running out, the problems of pollution & population explosion pose serious threats to availability of suitable quality of water for agriculture and human consumption. The worlds total water resources (Hydrosphere) makes an interesting study.

Component of Hydrosphere	volume 1000 Km^3	percent of total
World Oceans	1,370,000	93
Polar Ice	24,000	2
Terrestrial Waters	64,000	5
Atmospheric	13	0.001

Of the 64,000 million Km^3 of fresh water, virtually all of this is ground water located at varying depths under the soil leaving only 0.016% in lakes and an even smaller amount (0.0001%) as flowing streams & rivers. The Hydrological cycle, namely evaporation & subsequent precipitation brings all the fresh water that the world can use. Of all the uses man puts this water to, agriculture on a world wide assessment would account for nearly 90%. The U.N. studies have revealed that unless urgent, well planned efforts are co-ordinated to optimise water use in agriculture, the crisis for fresh water in the coming couple of decades could pale into insignificance, the oil crisis the world faced in the seventies. Apart from the above compelling circumstances for water use optimisation in agriculture, an interesting study made in India in recent times reveals some startling aspects on the irrigation options followed by our planners ever since we gained independence 40 years ago. The first revelation by our Central Water Commission was that the large number of Major & Minor irrigation projects we embarked on spending an aggregate of Rs. 28,000 crores(US$20 billion) was meant to bring under irrigation, a total area of about 25 million hectars. The actual coverage has been estimated at only 50% of this area. The cost of Major/Minor irrigation in our First 5 year Plan was Rs. 1,200 per hectare (US$100 approximately) whereas in our 7th plan it has shot upto over Rs.40,000 per hectare (US$ 2700). The second, even more startling revelation is that the water use efficiency, assessed only upto the delivery point in the farmers field is only around 30%. The loss by seepage & evaporation on a national scale is in excess of 70%. Very similar situation would emerge in most developing countries and therefore a serious rethinking on methods and proper priorities in irrigation planning is called for both in terms of water use optimization and financial resource allocations.

1.3. Problems of Agriculture in Arid and Semiarid Regions: Using ground water from aquifers by lift irrigation techniques has produced very remarkable results. This not only reinforces the concept that "small is beautiful" but also results in well controlled water use optimisation. In India, the irrigation water from Large & Medium irrigation schemes is almost free of cost and so invariably results in wasteful excess irrigation at the upper reaches of the canal network, often resulting in the tail enders going without water. Lift irrigation is established at the farmers expense and he pays for the pumping energy which automatically brings about a lot of discipline in water use. Modern Sprinkler and Drip systems are so economic in water use that nearly 3 times the areas can be effectively irrigated with the same quantity of water. The discharge requirements are so low that very much smaller pumps can cover large areas. Windmill operated pumps, solar photovoltaic pumps have all been successfully used particularly by the remote small and poor farmers to whom grid power or diesel engine power is unlikely to reach.

1.4. Conclusion : With this introduction to water management as a Plasticulute technology, the details of the many alternatives and techniques available would be coverd in the next 3 papers to be presented.

2. Lining of Canals, Water courses with plastic membrane to reduce water loss by seepage. Plastic membrane underlay in highly porous plant beds.

2.1 As already mentioned, the Indian experience with unlined canals and distributories over the very large network of irrigation facilities created in the country is a clear indication to developing countries to learn two important lessons, without having to commit the same mistakes. The first is that the estimated aggregate loss of water (calulated from all project headworks to the point of delivery to each farmer) is a whopping 70%. Instead of spreading inefficient irrigation projects (which have become atleast 25 times more expensive than when we started these schemes 40 years ago) and damaging ecology all over the place, injecting proper technologies to improve water use efficiencies would be more productive. The second important lesson is that whatever the effort required, totally indigenous systems have to be developed to save the merge resources of developing countries. Imported, high-cost automatic systems do not have relavance in our poor situations. Membrane lining is not all that complicated and indegenous capability can be easily and quickly developed.

2.2. Canal and Water course lining : Low Density Polyethylene film produced by the blown film extrusion process has been extensively used in India. The addition of upto 2.5% of the right particle size carbon black gives the film nearly 10 times the life agaist Ultraviolet exposure, but this should be very thorougly mixed in the polymer. Of late linear low density polythylene and even High Molecular weight HDPE has been used, where in view of the superior mechanical properties of these films, a considerable extent of downgauging is possible to save costs. Usually, where untrained labour is involved, 250µ (1000 guage) LDPE film can be used to start with and with a little field experience, 200µ (800 guage) or even slightly thinner guage LDPE black film can be used. Some typical systems are described in the sketches in this paper. What is relevant and most economical would depend on a variety of local conditions. The velocity of flow would dictate the overburden treatement that would stand. The angle of repose of the soil would dictate the overburden on sides, its slope and the F.S.L in the canal. In many situations, a mere mud overburden has been found adequate. The slides show some typical works carried out in India & Egypt.

2.3. Some random observations connected with membrane lining of canals.

2.3.1. It is always preferable to choose wide width film in order to minimize joints in laying the film. Joints need not necessarily be heat sealed. They can also be folded over a couple of times and depressed into a groove cut into the soil along joints.

2.3.2. While the thinnest film is also equally impervious to moisture, a thicker guage is chosen to prevent possible damage like puncutures while laying.

2.3.3. It is important to remove sharp edges in the soil excavations as also sharp roots etc. A mild tamping by using proper tools is recommended. A layer of sieved sand to act as a cushion is desirable before spreading the film.

2.3.4. The workmen should be asked to clip their finger nails and also use only rubber flat souled footwear, while working with the film.

2.3.5. Shallow canals should be provided with adequately paved cattle crossings so that they do not damage the film lining elsewhere.

2.3.6. Where nut grass problems exist as well as rodent/crabs, suitable steps to eradicate them may be necessary.

2.3.7. Due to the over 500% elongation property of the film, soil settlement etc. does not damage the lining.

2.3.8. Workmen should be cautioned against throwing sharp/metal tools over the film while working. Where the film gets accidentally damaged, patching with a piece of film & using bitumen adhesive could be done.

2.3.9. The fact that the film gets buried out of sight should not be allowed to be exploited by unscrupulous film manufacturers/contractors by using substandard quality of film.

2.3.10. The savings in water resulting from the use of this lining in small water courses can be collosal and is therefore to be enforced in the national interest of all developing countries. Since water from major irrigation projects is not paid for by farmers on the basis of quantity of water used, there is no incentive in India for the farmers to adopt any water conservation measures. To aviod build up of water table and consequent salinity damage, timely measures of preventing excess water use will help in the long run.

2.3.11. It would be interesting to know that a running canal was lined with LDPE without stopping the flow. This was possible as the depth of flow was within one meter. First the sides were defined and regularised with earthen bund. The film of adequate width and not too long was anchored with sand bags on the upstream end and the film at tail end (not more than 15 meters at a stretch) was held by a gang of people, low over the canal water level. The discharge Slowly depressed the film to the bed and after anchoring it all over with sand bags overburden, the down stream end was lowered. Adequate over lap was given to the next 15 meter length which was similarly laid. Nearly one KM was covered in 2 days.

2.4. Use of Plastic membrane underlay in porous soils for Agriculture : In very sandy soils (such as in Israeli deserts) irrigation water does not stay in the root zone of crops and the soil wilts after irrigation at a fast rate. A very thin plastic membrane (as low as 10μ or 40 guage) can be laid at a depth - upto 1 meter - below the soil so that moisture penetration beyond this level is held in check. This technique was successfully used on many hectares in the Negev Deserts in Israel and they had even developed a tractor drawn implement which would unroll a one meter width film at a depth and the soil would get over turned by the tool as the tractor proceeded. However it is necessary to leave a gap between adjacent layers of film to constitute a 10% gap in the total area covered to allow any accumulation of salinity by repeated irrigation to be washed down into the lower soil levels. Israel does not appear to follow this technique any longer as they have started adopting Drip system of irrigation extensively. In India this has been tried on growing lawn quite successfully. One stretch of about 1/2 acre was covered for growing paddy and it was spectacular - from the same water source which could hardly sustain one crop of paddy in a year. Now three crops are being raised. The interesting feature of this installation was that a bulldozer was available and used for excavating the soil to this depth and shift it into a mound all round. The bulldozer, which was hired from the Department of Agriculture of the Government was not available to doze back the soil after laying the film. Village hand labour was employed for this part of the work. Although it took a longer time to accomplish this part of the work, it worked out to be incredibly cheaper than the bulldozer hiring. This teaches us two lessons. One that all developing countries who suffer from Unemployment and Underemployment in rural areas should avail of all opportunities to give them gainful employment. Secondly, it may also quite often work out cheaper than machinization. Large tracts of land in developing countries where water is meagre and soil, highly porous can usefully convert arid and semi-arid areas in to productive, useful and easily irrigable areas

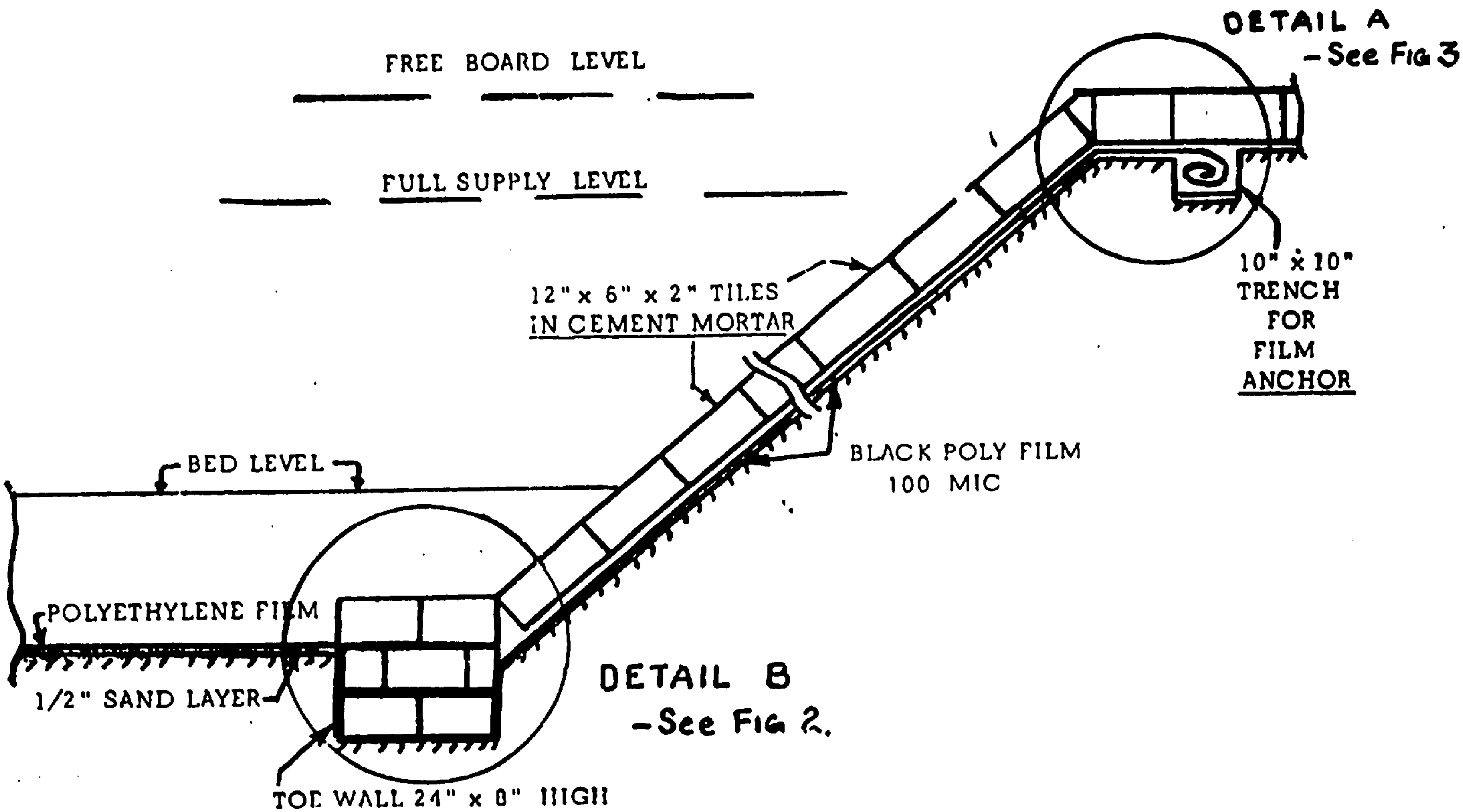


FIG. 1 : BLACK POLYETHYLENE FILM LINING
- SOIL COVER ON BED
- SINGLE TILE IN CEMENT MORTAR ON SIDES

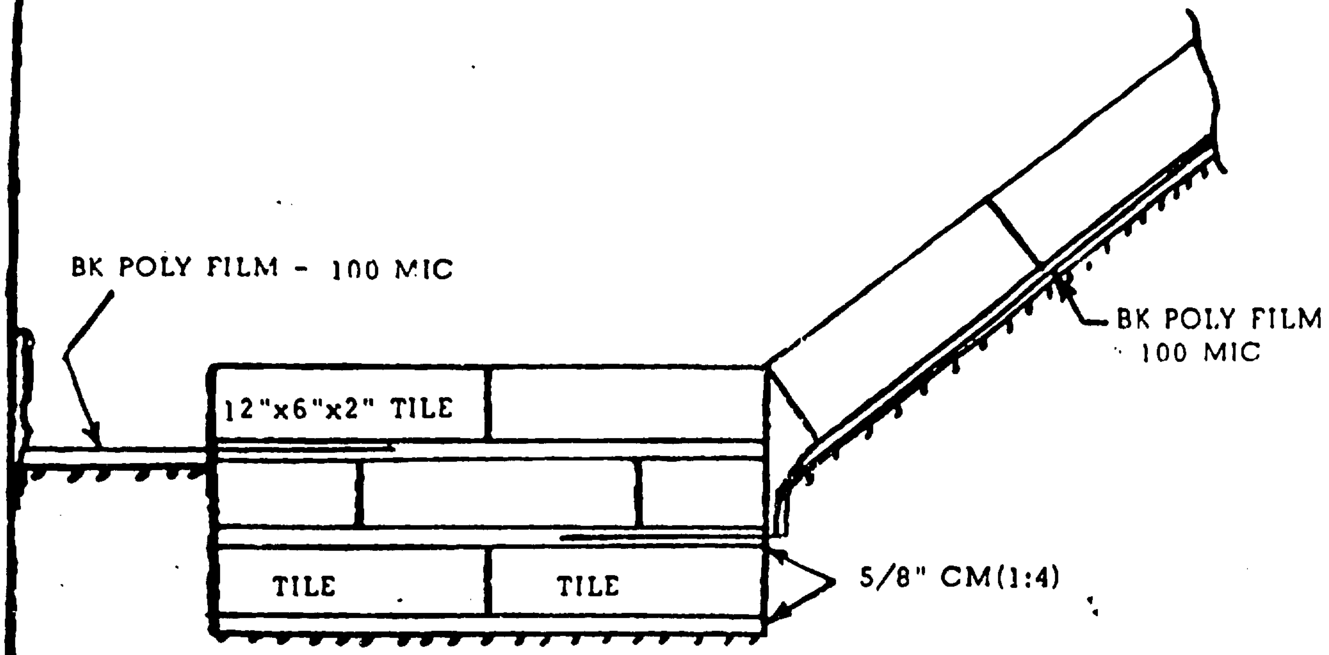


FIG. 2 : TOE WALL CONSTRUCTION DETAILS

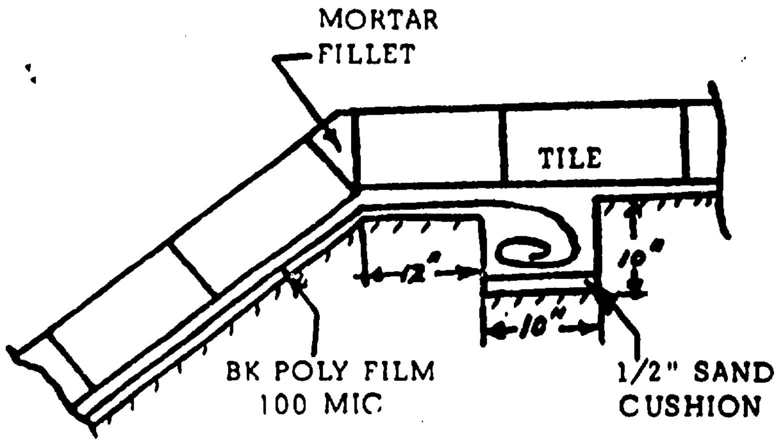


FIG. 3 : FILM ANCHOR ARRANGEMENT DETAILS

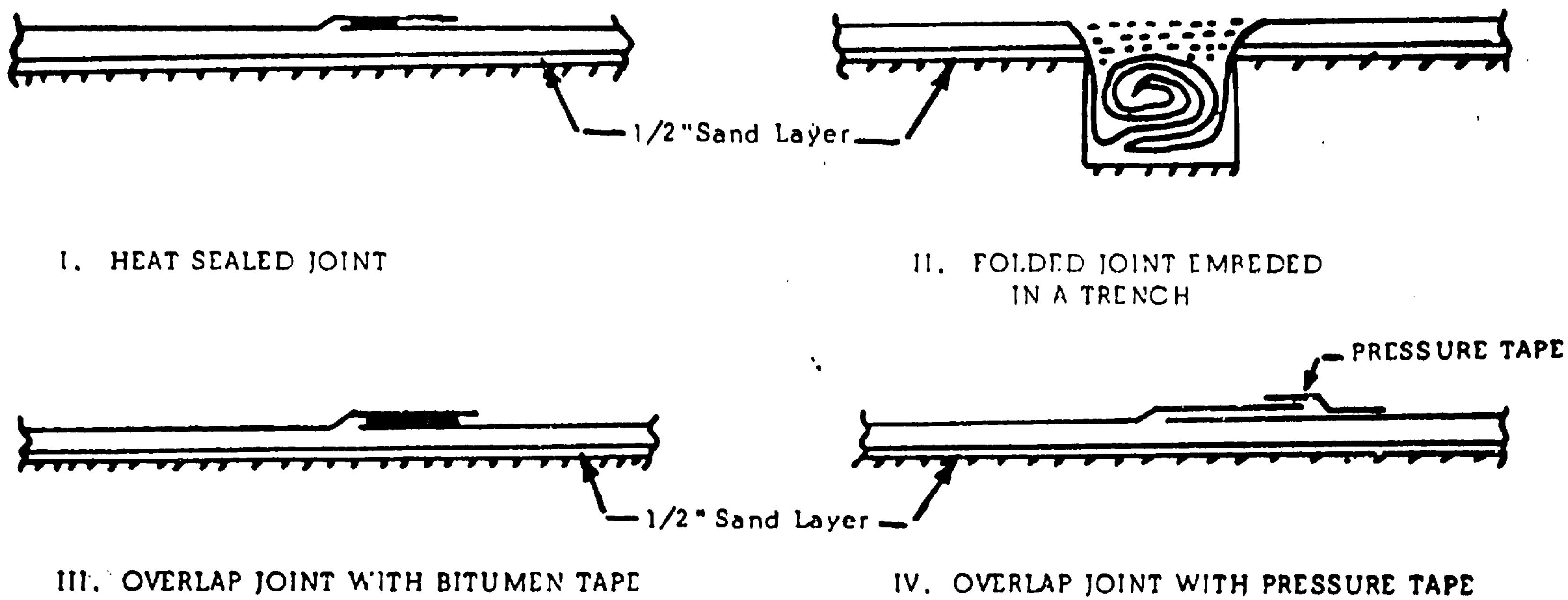


FIG. 4 : RECOMMENDED TECHNIQUES FOR POLY FILM JOINTING IN CANALS

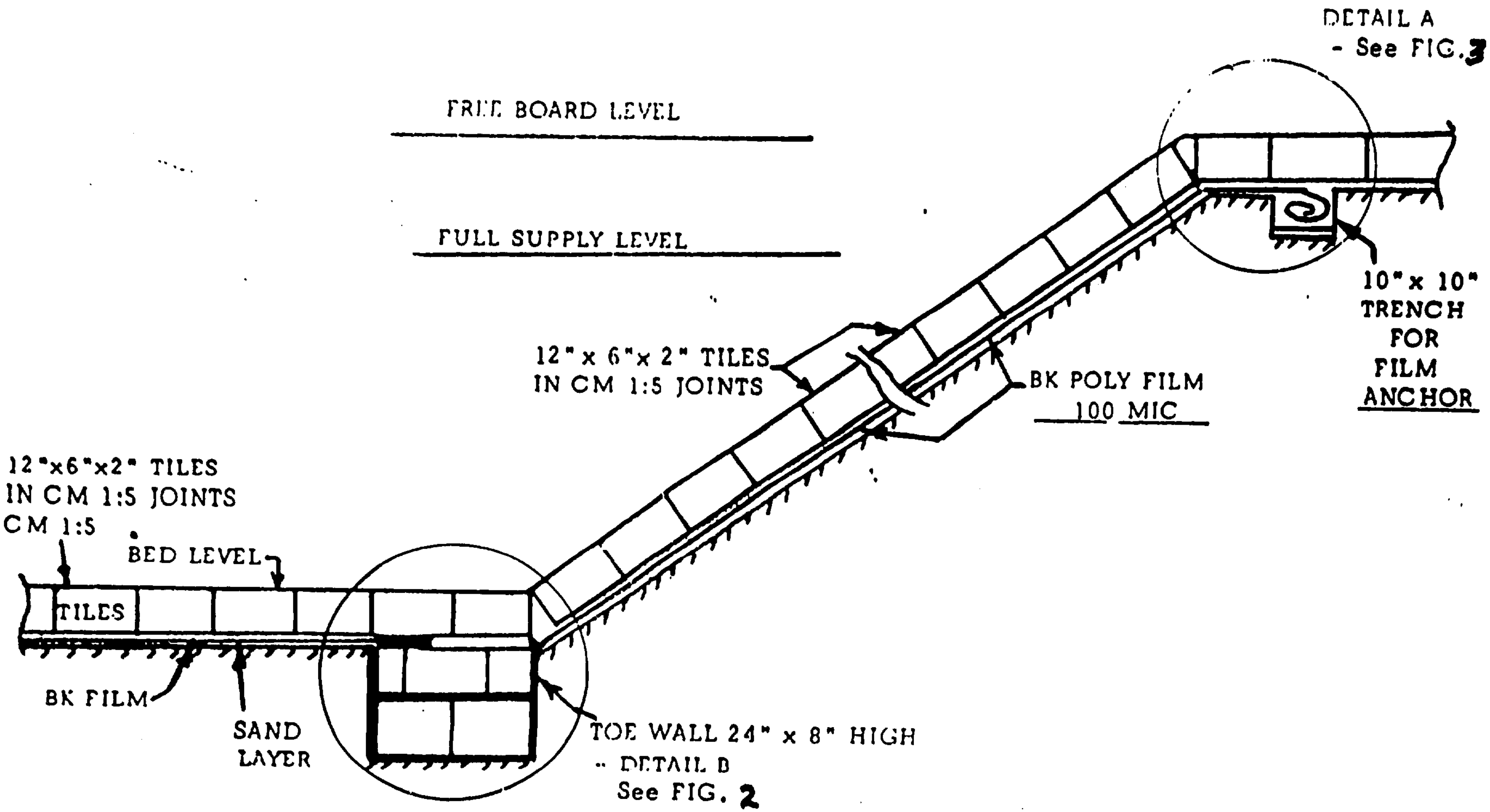


FIG. 5 - BLACK POLYETHYLENE FILM LINING
- SINGLE TILE IN CEMENT MORTAR
ON BED & SIDES

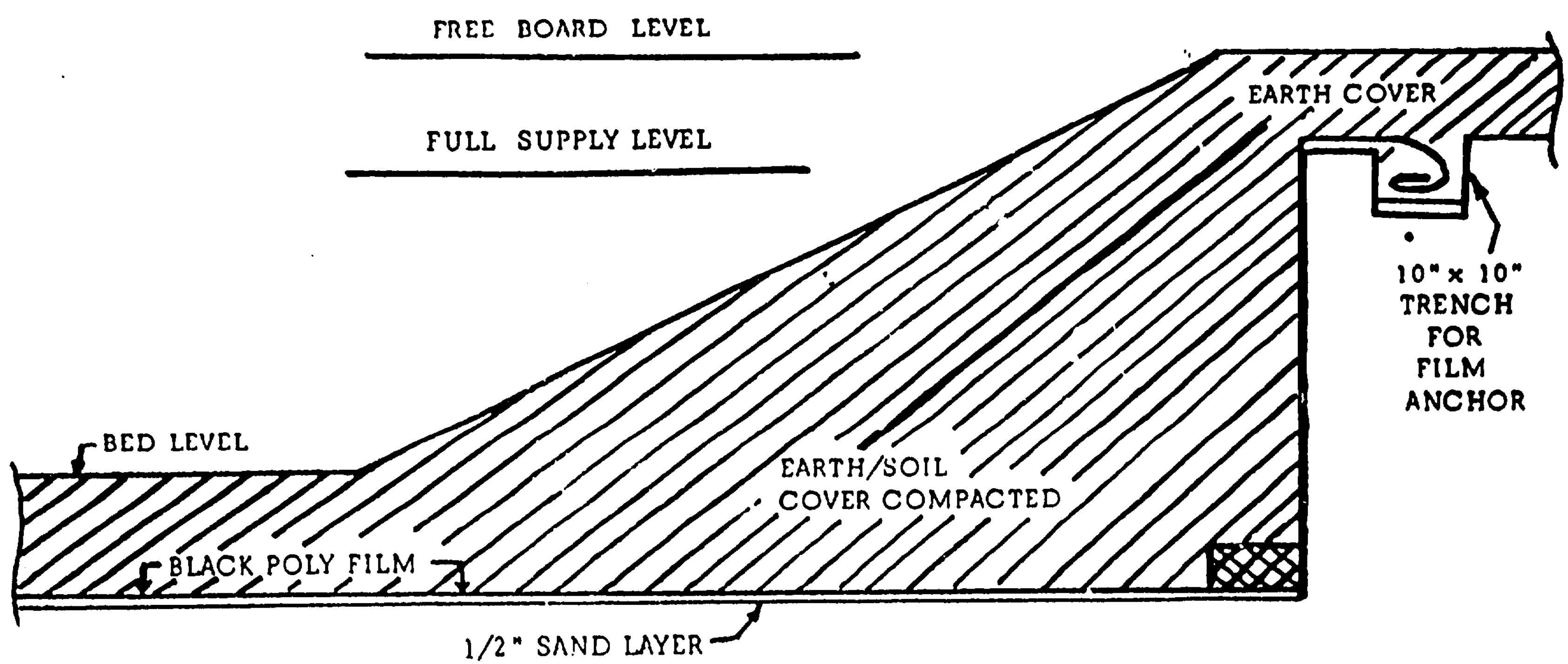


FIG. 6 : BLACK POLYETHYLENE FILM LINING
- SOIL COVER ON BOTH BED & SIDES

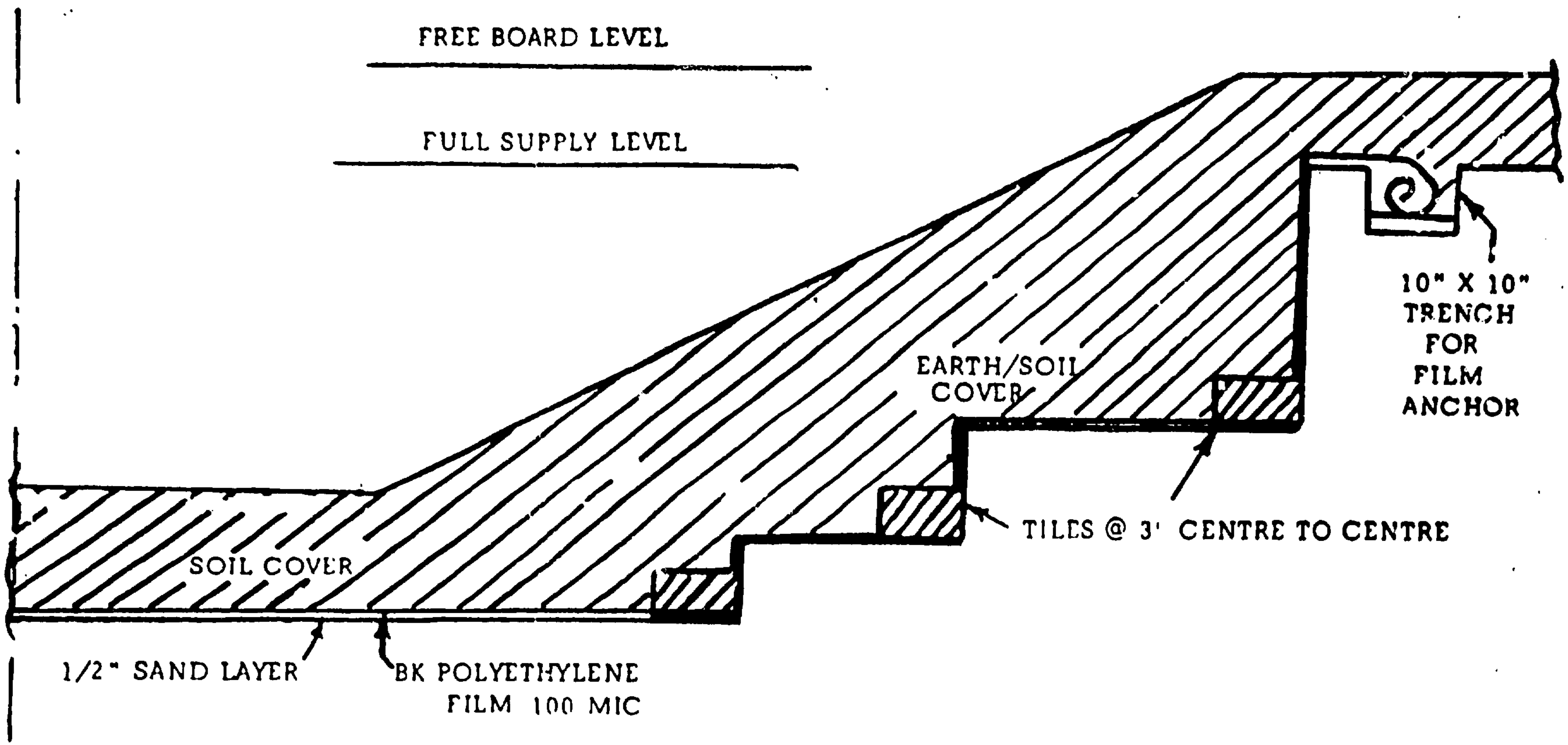


FIG. 7 : BLACK POLYETHYLENE FILM LINING
- SOIL COVER ON BOTH BED & SIDES

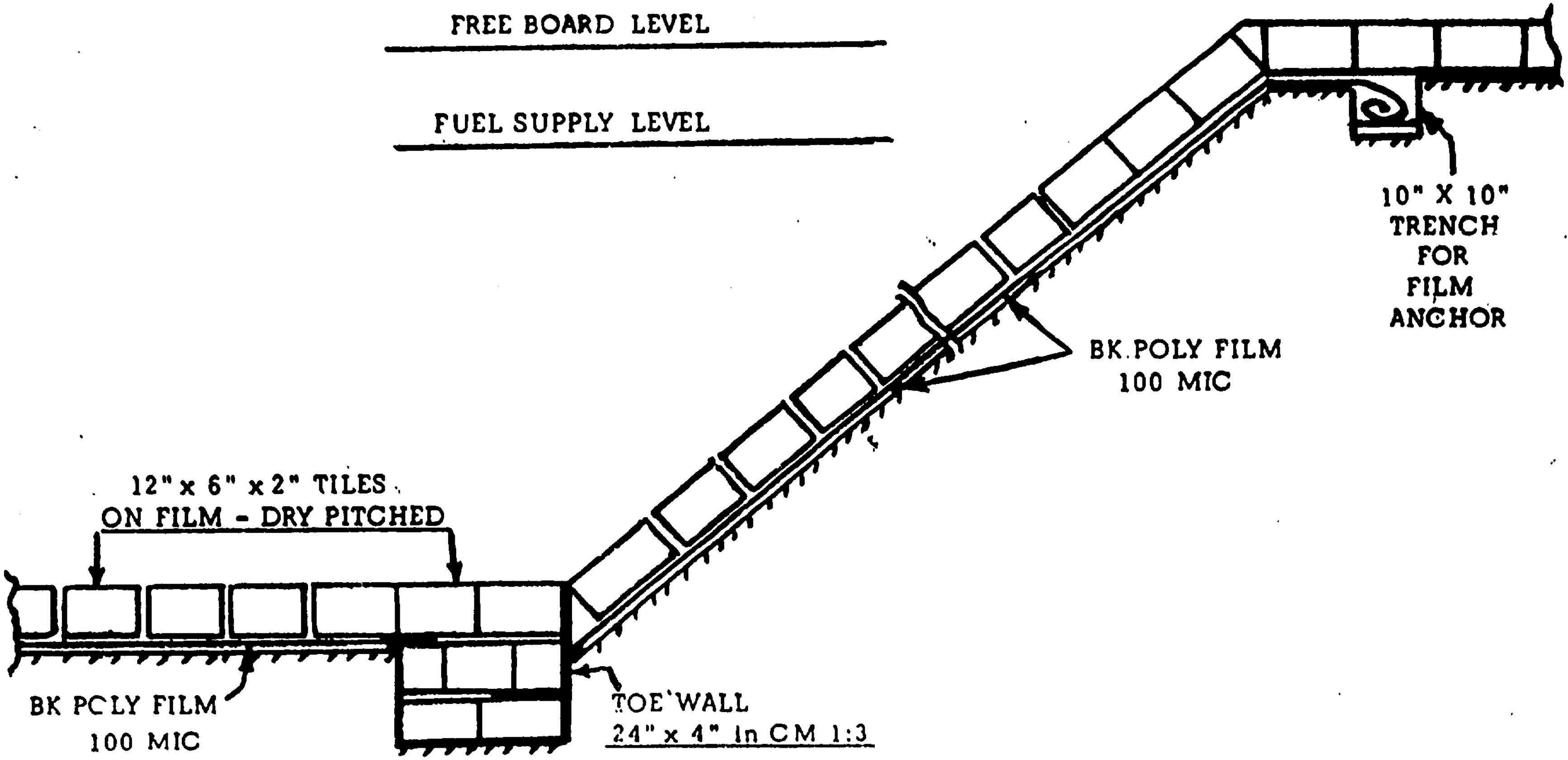


FIG.8 : BLACK POLYETHYLENE FILM LINING - DRY TILE COVER BOTH ON BED AND SIDES

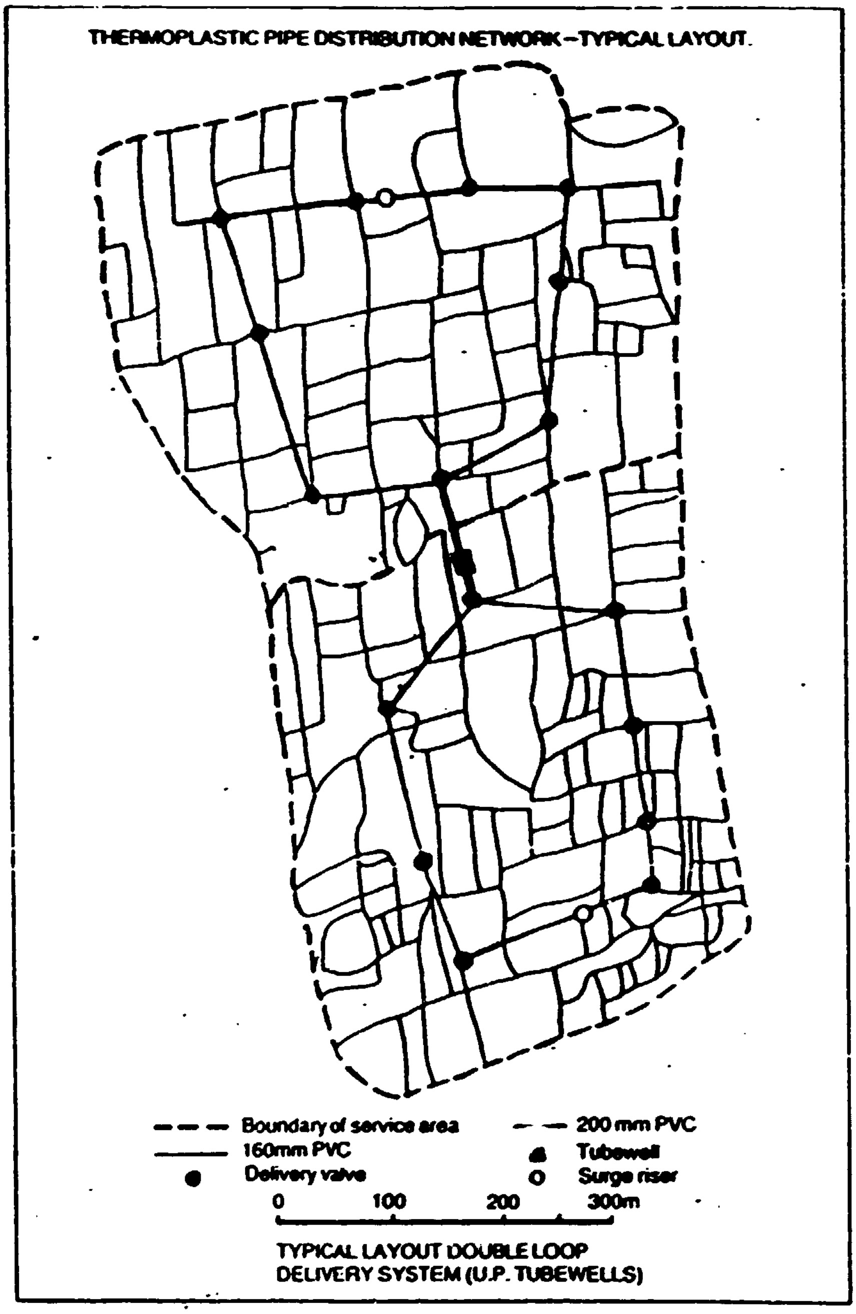
3. Rain Water harvesting with plastics - Lining storage reservoirs with membrane - Using integrated system connecting bore wells with buried network of pvc pipes with control valves.

3.1 The problem of getting fresh water in seasons when it does not rain has to be seen in many parts of the world to understand the severity of the struggle. In places where you have some rains, even for a few weeks in the whole year, the terrain and soil conditions are so adverse that very little of this water can stay even in the aquifers to be able to pump up in the lean and summer months. In the mediteranian coast of North Africa, the rain mostly drains into the sea and is therefore lost. There have been efforts from time immemorial to impound the rain water into subterranian cavities scored out in hardened soil locations. At first a vertical hole, less than a meter diameter is burrowed and at a depth, the hardened porous sandy earth is scooped out to form a some what globular hollow. The sides and all surfaces are then treated with a bentonite like clay to make the walls impervious. Such strong storage tanks for rain water, which is diverted into it from the surrounding area, still exist. The impervious plastic membrane which is very effective and not so expensive has helped to solve this problem and today very large underground as well as open tanks which have nearly zero seepage losses, have been done successfully. It is however important to periodically desilt these storage reservoirs as every rain washes into them, plenty of soil along with water. The slides show the sequence of operations. The most important savings that can be achieved with using the impervious membrane is the savings in the use of very lean cement/sand ratios for the morter. The lead in zones for the water, however, have to be properly plastered with richer cement ratio to avoid the scouring action of rain water that rushes in. In some places, mere soil cover has been found adequate for the bed of these tanks. If the side slopes can be accomadated within the angle of repose of the soil involved, even there, soil overburden would be found adequate. A fencing around such open tanks would become necessary to prevent tresspass, particularly by cattle.

3.2. **Using integrated irrigation system connecting bore wells with buried network of pvc pipes with controlling valves :** In the vast Arid and Semi Arid zones of the developing world, land holdings are small, the farmers live under hopeless conditions. Establishing bore wells is too expensive for such small holders. Investment agencies find it uneconomic to advance funds and quite often, on top of all this the yields from tubewells is far from adequate if conventional channel type of wasteful irrigation is to be adopted. The World Bank appreciated a proposal for a co-operative effort in such a situation and one tube well typically with a capacity of 40-50 litres/second was able to cover a command area of 100 hectares where nearly 100 individual plots can get an assured irrigation, once a week without any transit losses. In the Indian state of Uttar Pradesh, the World Bank funded the establishment of 500 such tubewell schemes in the early 80s and these have truly revolutionised farming in vast areas, conserving enormous quantities of water and pumping energy. Farm holdings range from as low as 0.1 hectares and land values are high which makes it very wasteful to have open channels for irrigation. The field spread of irrigation water is by gravity and a scientific crop rotation is propogated. Without this pipe network system, a tubewell discharge cou[illegible]ardly cover a few hectares. The pipe network ensures against starvation for the tail enders. By [illegible] of valves the irrigation is controlled, proportionate to the area served by each and are closed and opened on the basis of a properly worked out time schedule. One of these total system is brought out by the schematic plan annexed. The hydraulic design of the double loop system covered in the annexure is near perfect on economies of pipe sizes chosen and uniformity of discharge.

3.3. While the buried pvc pipe network system proves efficient and economical with tubewell and pumps, it can also be extended to outlets from irrigation canals provided we are operating in areas where we have operating level differences between canal and field which is adequate to establish discharges of required quantities of water, using gravity flow. World Bank funded a project of this type in the Indian State of Kerala - Kalada Project.

Box 6.4


THERMOPLASTIC PIPE DISTRIBUTION NETWORK – TYPICAL LAYOUT.
Boundary of service area
200 mm PVC
160mm PVC
Tubewell
Delivery valve
Surge riser
0
100
200
300m
TYPICAL LAYOUT DOUBLE LOOP
DELIVERY SYSTEM (U.P. TUBEWELLS)

even more, the grade in each type. The very best for every single item of software is an important criterion, if Drip Technology should find extensive acceptance in the country. For instance, it would not be adequate just to add 2 to 3% carbon black to LDPE in making pipes. The particle size of carbon black and what is more, the thorough dispersion of the incompatible carbon in the polymer are important factors to obtain maximum Ultra-Violet exposure resistance. Again, if the proper polymer grade (in terms of M.F.I. etc.) are not chosen, failures in the field can result. The grades of PVC, P.I.B. rubber, LDPE, HDPE, glass filled Polycarbonate, etc. etc. have all to be properly looked into in developing components.

Complete System Approach :

For many years to come, development of Drip Technology in developing countries can only succeed if the farmer is assured and delivered a complete package with adequate guarantees regarding performance over a reasonable period. The day when they can buy components and establish successful systems on their own is quite far off. The complicated hydraulic calculations regarding discharge vis-a-vis pipe network design, corrections for contour complications study of water quality in relation to filtration requirements, compatibility with fertilizer solutions, corrective measures for algae presence in the water, calculations and proper assessment of plant water requirement, soil analysis and structure studies, etc. etc. all need the expertise of an engineer, agronomist, plastic technologist to help the Drip technician to arrive at a proper system design. Once the system is designed and established carefully on the field, its upkeep and service needs so much less attention. The system established properly should be such that lay men could be trained to operate and maintain it. This training of local work men should be part of the responsibility of the system supplier. Complete fertigation regime should form part of the system as without fertigation through the Drip System, more than 60% of the results attainable with the whole technology would be lost. Savings in the expensive fertilizers of the order of 25 to 30% is possible with this technology.

Which System

In Computer parlance the common saying is "Garbage in, Garbage out". With Drip Irrigation Systems, cheap and inexpensive systems cannot produce the optimised and dependable results that are so universally reported. Inadequate inputs in the System Design can create a variety of problems and may fail eventually to produce any results. The trend in advanced countries is to automate systems and even computerise the working. The main purpose of the whole exercise for them is to cut down labour. To us in developing countries for many more decades this cannot be the situation. We need simple and inexpensive adaptations of the Basics of this technology and this has been achieved in no small measure, by a few firms that have developed systems and established them in the fields on a variety of crops. Whether it should be a system working on pumped mains or from an overhead tank with suitable gravity head, etc. would depend on conditions prevailing in each place. In one analysis, what is important is a trouble-free, long life system that lasts the crop life substantially. In terms of cost benefit analysis, any initial extra cost to achieve sustained trouble-free results is more important than saving a few Rupees here and there. A well designed system should produce yield increments definitely 30% plus on any crop; this in addition to savings in water, labour, fertilizer, etc. Under the heading "Technologies", it would be necessary to deal with some questions often asked by farmers, bankers, etc., to complete the purpose for which this report is being prepared. Also, a list of Do's and Don'ts with Drip Irrigation Technology. Both these are covered by the last few pages so that any one can always refer to these for clarifying doubts.

Applications :

In terms Agronomic inputs, Drip System establishes the most ideal and optimised conditions to obtain best plant response. The only constraint against its adoption more extensively is the capital investment it needs. Yet within 10 to 15 years of its introduction (thanks to the part played by Plastics), in 1974, in all countries put together, over 64,000 hectares had been covered by this technology. Since then in these 15 years, the figures have galloped and the spread is universal. Almost all plants have shown significant response and the technology is fast spreading. By a proper, scientific assessment of the consumptive water use by each plant, under the highly varying Agro-climatic conditions in various parts of the world, attempts are made to establish near "bone levels" of irrigation. The use of Standard "A" Type Pan Evaporimeter, and working out "pan factors" have helped a great deal to assess plant water requirements more accurately. A large number of field conditions like soil moisture level/holding capacity (dictated by humus content), humidity in the atmosphere, wind velocities, temperature conditions, potential Evapotranspiration from plant which bears a relation to plant canopy, levels of nutrients in the soil in relation to the stage at which the plant growth needs each nutrient, etc.etc. can all be fed to a Computer to monitor the inputs of water/nutrients quite accurately. It is therefore not surprising to find a very large number of Drip Installations in the advanced countries being operated by a Central Computer.

Case Histories :

Drip Technology has found extensive commercial acceptance on a variety of crops all over the world which is too big a list to cover: Orchard crops; Vines; Row crops of Vegetables, Oilseeds, Ornamentals, Greehouse and tunnel agriculture, flowers and even cereals. Some application results are quoted below, first from abroad and secondly in India:

Some Drip Irrigation Success Stories From Abroad :

1. South Australia is the driest state in the iest continent. Water constraints are severe. Drip Technology has enabled some of the best known Vineyards being established in the southern districts like Clare Valley, Riverland, Barossa Valley with outstanding results. The young Vines coming into crop a clear year earlier than normally expected and drip on existing Vines bear more heavily. Almonds, in South Australia, Victoria N.S.W. and apples, black currants in Tasmania, Citrus and Olives in North Victoria and nuts and tropical fruits in Queensland have all gone to Drip Irrigation, with excellent results.

2. In the Arabian Gulf country of Abu Dhabi Drip has transformed even under a most inhospitable desert climate (of temperature reaching 60°C and virtually no rainfall with water in borewells having 2000 ppm plus of salts) large areas into lush green Eucalyptus forests. Within 3 years of planting, the trees had grown 4 Metres high.

3. In Renmark, South Australia, ni ows of Valencia Oranges were put on Drip in 1969 on the basis of "no like, no Keep", (i.e.) they would be paid for at the end of the year, if found successful and if not, the Drip System would be removed without any financial cost to the grower. At the end of the first year, it was not only paid for but a further nine rows were covered and since then even 40 year old trees have been put on Drip Irrigation with remarkable results. It now covers also navel oranges, Grape fruit, etc. and all new plantings are Drip Irrigated. Grape fruit in the third year have shown outstanding progress on Drip Irrigation. As this Farm gets its River Murray water for 11-days on a three-weekly basis, it is stored in a 100,000 gallon tank at a high point in the property to keep the Drip Irrigation going.

4. Gramp's Orlando Wines, are one of the largest Wine Companies in Australia and grow extensively in the Barossa Valley in South Australia. Drip in that area supplements the 23 rainfall by adding 7 per annum. The first installation done in 1973 on Shiraz Grapes proved that production starts one year ahead (i.e.) within 3 or 4 years when it is normally achieved in five. The very next year in 74, the area was more than doubled and since then the spread is rapid. They dispense fertilizers through the system and therefore their return on investment for this technology is easily recoverable in 4 to 5 years of yield. The bore wells supply about 3000 gallons an hour, sufficient to irrigate 3000 Vines (or six acres) in an hour. Theirs is a story of complete success.

5. Krondorf Winery in the Barossa Valley in South Australia now has 60 acres under Drip Irrigation, producing excellent results. The young plants grew up in half the time (one year against the normal 2 years), and with the available water from the bore wells, they could only cover one acre per day with sprinklers (i.e.) they could give the 2nd Irrigation to each one acre area only with 60-days interval. With the entire area now covered with Drip System, they can irrigate every area once in 10 days.

6. Shortage of water or improving water use efficiency was not the criterion that made Mr. George Spencer of Sevenhill, South Australia, go for Drip Irrigation for his 12 acres of grapes which he is expanding to 33 acres. A dam on his property impounds 5-million gallons which does not suffer even in draught years. The control of water towards the maturing stage of the grapes where the sugar-acid content is exactly right and then the water can be cut off to get perfect finish is what he feels in the biggest advantage with Drip System. His grapes were adjudged the best in that area.

7. Angle Vale Vineyards Pty.Ltd. near Adelaide, South Australia has adopted Drip Irrigation on 600 acres of Cabernet Sauvignon, Shiraz and Top dry white varieties of grapes and have subsequently ex-

tended it to cover a further 110 acres of other varieties. Only 17 inches of rainfall, all in winter and the warm dry summer conditions help to ensure clean even ripening and freedom from disease. An 8 mile long (13Km) asbestos pipe 8" dia. brings reclaimed domestic and industrial waste water from Adelaide after treatment. It is almost clear and odourless and is passed through a 40-mesh. Salinity of 1500 ppm and algae are both problems but periodic cleaning of drippers (2 men cover 50 acres in 2 days) - blocking of 2-1/2 to 5% of drippers - ensures algae problems being overcome. The salinity as such cannot trouble the plants, particularly when the rains wash down the accumulation. Lateral line-ends are also flushed once in two or 3 months; The use of fertilizers has been found unnecessary as the effluent provides all the nutrients. Several trophies for the best varieties of vines have been won by this largest drip irrigated Vineyard in the world entirely dependent on reclaimed waste water.

8. In Mildura, Victoria, Australia, bordering New South Wales on the Northern side of Murray River, Mr.Dudley Marrows has covered 186 acres of Citrus - Grape fruit, navel orange and mandarines with Drip Irrigation with very good results. Since water is pumped straight from the river elaborate filters have been installed. The trees have developed uniformly big in size and fruits from Drip Irrigated area is one or two sizes larger and all of a higher quality.

9. In the picturesque Huon Valley in Tasmania, there is enough annual rainfall. Yet, with local water shortages and dry months, Drip Irrigation has helped Mr. Mike Salter to develop 73 acres on Apple - 60 acres on Drip and the rest on overhead sprinklers. He uses 150-mesh stainless steel filters for the water from small creek dams and bores. The summer of 73-74 which turned out to be the driest and hottest on record would have wiped out the entire Orchard if drip system was not there to save it. The comparison between the Drip and the Sprinkler area is convincing in every aspect of the Orchard.

10. Adult Apricot trees in Loxton, South Australia were doing so poorly a few years ago that a decision to pull them out was almsot taken. However for other reasons, the orchard had to be converted to Drip Irrigation and within 4 years of conversion, the trees converted themselves from biennial cropping to bearing well every year. Water consumption in the aggregate was cut down to half. The quality of fruits - which are all for drying - the yield quantity per tree again improved.

Cultivation and other laborious work reduced drastically. The trees all over the orchard were healtheir with no salt damage (which is a common problem in the area). No problems of drainage which was so acute with furrow irrigation. Mr. Des Nitschke, the owner says "I've had terrific results with Drip Irrigation with better fruit, less work less water --- what more can you ask from an irrigation system."

Some Indian Success Stories With Drip Irrigation :

While results from newly planted orchard crops cannot be quantified (the earliest Indian Drip Installations which was on account in 1979 is yet too early to judge by quantity of yield) the plant response generally, compared to non-drip irrigated plants almost alongside and of the same age, gives a good comparison. The more spectacular Indian experience is with old trees (16 to 17 years old) that have been changed to Drip System, in quite a few places. These are reported below, in addition to a few other crops which have been commercial successes:

1. At the Elite Seed Coconut Farm at Navlock in Ranipet - Tamil Nadu, 397 plants in a total of over 3000, planted in alternate rows of Tall and Dwarf in 1978, were covered with Drip Irrigation. These 397 plants in one corner have come up remarkably whereas the rest that were pot watered (using more water wastefully) suffered a mortality of 48% within 16 months on account of the very adverse conditions of soil, vagueries in labour dependant irrigation etc. The department of oilseeds of the Government of Tamil Nadu, who own this Farm is strongly of the opinion that under such sandy soil conditions no plantations should be attempted without providing a satisfactory Drip Irrigation System.

2. The Children Garden School Madras, switched to Drip Irrigation, their Water Melon Crop which they had raised on the same plot, the previous season. Using only 1/5th the total quantity of water over the crop duration, the harvest was three time in terms of number of fruits. What was even more spectacular was that the size of the Drip irrigated fruits were nearly double the size of fruits taken