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Cycling Tile Drain Water for Crop Production and Reclamation of Aquic Haplargid Soil

M. Qadir, A. Ghafoor, G. Murtaza and H.R. Ahmad

Abstract - Pakistan is falling short of canal irrigation water. Most of the ground water is brackish. Large areas are affected by salinity/sodicity. An effort was made by using tile drain water (EC = 2.9-3.4 dS m^{-1}, SAR= 12.0-19.4, RSC = 4.6-10.0 $mmol_c$ L^{-1}) to irrigate rice and wheat crops on a saline-sodic field (EC_e = 24.3-32.3 dS m^{-1}, SAR = 56.6-77.5). The treatments were: 1) tile drain water without amendment, 2) soil-applied gypsum @ 50 % gypsum requirement (GR) of the 15 cm soil surface, 3) sulphuric acid mixed in irrigation water equivalent to residual sodium carbonate (RSC) of water, and 4) farm yard manure (FYM) addition to the soil annually @ 25 Mg ha^{-1} before rice transplanting . During the studies, three rice and three wheat crops were harvested. After harvest of the sixth crop (wheat), the overall treatment effectiveness to decrease the EC_e and SAR of the soil was in the decreasing order of gypsum > FYM > sulphuric acid ≈ tile drain water. Rice crop produced lower yields than those of wheat. The overall treatment effectiveness for crop yields was found to fit the order: FYM > gypsum > sulphuric acid > tile drain water.

Key Words: Brackish water, Salt-affected soil, Soil reclamation, Gypsum, FYM, Rice, Wheat

1. Introduction

Despite having the largest continuous gravity flow canal system for irrigation, Pakistan is falling short of good-quality water due to increased cropping intensity over the years (Mohtadullah *et al.*, 1993). Ground or drainage water may supplement irrigation needs but its quality is questionable because about 75 % of this water is hazardous (Malik et al., 1984; Ghafoor et al., 1991). About 5.73 x 10^6 ha area of the country is salt-affected, out of which 60 % is saline-sodic (Muhammed, 1983).

The development of technology for using drainage water at or near the source for crop production during reclamation of salt-affected soils may increase the extent of the productive area as well as crop yields per unit area (Minhas, 1996). Local utilization will reduce the disposal problems of the effluent and thus will help reduce environmental degradation. This study was carried out on a saline-sodic field for three years to evaluate different soil or water treatments for crop production and reclamation of a saline-sodic soil.

2. Materials and Methods

A saline-sodic, sandy clay loam field belonging to the Khurrianwala soil series (Coarse loamy, mixed, calcareous, hyperthermic, Aquic Haplargids) was selected for experimentation. This series is developed in late Pleistocene alluvium and occurs in level to nearly level islands of scalloped inter-fluvial material in old river terraces under arid and semi-arid climates. The field site was at sump S1B9 of the Fourth Drainage Project Area (FDPA), district Faisalabad. At present, 79 sumps are discharging drainage water into surface drains in this area.

The treatments were arranged in a randomized complete block design with three replications using plot size of 171 m^2. All the treatments were irrigated with tile drain water (EC = 2.9-3.4 dS m^{-1}, SAR= 12.0-19.4, RSC = 4.6-10.0 $mmol_c$ L^{-1}). The treatments were: T_1) control, T_2) soil-applied gypsum @ 50 % gypsum requirement (GR) of the 15 cm soil depth, T_3) sulphuric acid mixed in irrigation water through fertigation equivalent to it's residual sodium carbonate (RSC), and T_4) FYM addition to the soil annually @ 25 Mg ha^{-1} before rice transplanting.

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After lay out of the experiment, composite soil samples from three randomly selected sites in each plot were collected from 0-15, 15-30, 30-60, 60-90 and 90-120 cm depths. Particle-size analysis was carried out by Bouyoucos hydrometer method. Determinations of saturation paste pH, EC_e, soluble $Ca^{2+} + Mg^{2+}$, Na^{+}, and gypsum requirement were done according to the methods of U. S. Salinity Laboratory Staff (1954). Sodium adsorption ratio (SAR) was calculated as $SAR = Na^{+} / [(Ca^{2+} + Mg^{2+})/2]^{1/2}$. The irrigation water was sampled weekly. The analytical methods were the same as used for the analysis of soil saturation extract. Residual sodium carbonate (RSC) was calculated as $RSC = (CO_3^{2-} + HCO_3^{-}) - (Ca^{2+} + Mg^{2+})$.

Gypsum was applied in T_2 @ 50% GR of the upper 15 cm soil depth. Sulphuric acid equivalent to the RSC of the tile drain water was applied through fertigation in T_3 at each irrigation. FYM was applied in T_4 each year @ 25 Mg ha^{-1} before transplanting rice. After rice harvest, wheat was grown. During the studies, three rice and three wheat crops were harvested. After each crop harvest, composite soil samples were collected from each plot.

3. Results and Discussion

The treatment effects causing changes in soil EC_e and SAR are being expressed in terms of percent increase/decrease over the respective original level in each treatment. The relative efficiency of the treatments for soil reclamation is based on the figures given in parenthesis in Tables 1 and 2. This was done to overcome the difficulty arising from the variations in soil EC_e and SAR values before the start of experiment. This type of variation is common in salt-affected fields. Soil samples were collected and analysed after each crop harvest, but the treatment effectiveness has been presented after the harvest of the last crop.

3.1. Soil salinity

The original soil had higher concentrations of soluble salts (24.3-32.3 dS m^{-1}) in the surface 15 cm layer. The lower depth samples showed a gradual decrease in soil salinity with increasing depth. At the 90-120 cm depth, the EC_e values were around 4 dS m^{-1} (Table 1). The higher values of EC_e at the upper depth were because of the continuous evaporation from the soil surface because the field had not been under cultivation for more than 40 years.

Table 1. Effect of reclamation treatments on EC_e of the saline-sodic soil after growing six crops

Treatment	Soil depth (cm)					
	0-15	15-30	30-60	60-90	90-120	Mean
			Original soil (May 1993)			
Tile drain water	24.3	8.5	5.7	3.5	3.5	9.1
Gypsum	32.3	11.2	6.2	6.2	4.0	12.0
Sulphuric acid	24.3	9.5	8.7	5.9	4.0	10.5
Farm yard manure	25.3	13.6	7.1	7.5	3.9	11.5
			After wheat harvest (May 1996)			
Tile drain water	10.4 (-57.2)	9.2 (+8.2)	7.8 (+36.8)	7.1 (+102.9)	5.5 (+57.1)	8.0 (-12.1)
Gypsum	9.3 (-71.2)	7.6 (-32.1)	4.6 (-25.8)	6.6 (+6.4)	5.1 (+27.5)	6.6 (-45.0)
Sulphuric acid	11.2 (-53.9)	9.4 (-1.1)	8.7 (±0.0)	5.3 (-10.2)	4.6 (+15.0)	7.8 (-25.7)
Farm yard manure	11.2 (-55.7)	9.0 (-33.8)	6.0 (-15.5)	5.3 (-29.3)	5.4 (+38.5)	7.4 (-35.7)
LSD	4.0^{NS}	4.2^{NS}	4.0*	3.1^{NS}	2.5^{NS}	1.2*

Figures in parenthesis indicate percent increase (+) or decrease (-) over the respective original EC_e levels.
^{NS} = Non-significant * = Significant at $p < 0.05$.

After the treatment application and crop cultivation, leaching of soluble salts started gradually from the surface soil. Analysis of the soil samples taken after harvest of wheat (1995-96) indicated that in all the treatments more than 50 % of the soluble salts were leached away from the surface soil to the lower depths. The leaching of salts from soil surface caused a slight increase in EC_e in the lower soil depths. On the whole, the profile salinity was decreased in all the treatments. The treatment effectiveness to decrease soil salinity was found to fit the order: gypsum > FYM > sulphuric acid > tile drain water.

3.2. Soil sodicity The occurrence of sodicity (SAR) in the original soil showed a pattern similar to that of salinity distribution in the soil profile. The surface soil had SAR values in the range of 56.6 to 77.5. After harvest of the last wheat crop, the soil surface SAR values were found in the range of 20.7 to 28.3. A decreasing trend in SAR was observed for all the soil depths. However, the treatment effectiveness was more at the upper soil depths than the lower ones. The gypsum and FYM treatments differed non-significantly but performed better than the acid and tile drain water treatments.

The decrease in SAR in the gypsum treated soil may be attributed to increased soil solution Ca^{2+} resulting from gypsum addition and promoted displacement of adsorbed Na^+ followed by subsequent leaching. The decrease in soil SAR in the FYM treatment was probably due to the decomposition of added organic matter that helped in lime dissolution and provided Ca^{2+} for the Na-Ca exchange at the clay complex. It is well established that once a calcareous sodic/saline-sodic soil is managed for crop cultivation, some Ca^{2+} is made available through the dissolution of soil lime under the action of plant roots and soil microorganisms (Qadir et al., 1996).

A larger decrease in SAR in the gypsum treated soil than the one under acid treated water irrigation was due to the fact that the acid was applied as a water treatment to neutralize its high RSC only. Gypsum provided Ca^{2+} that was directly involved in Na-Ca exchange followed by leaching of the replaced Na^+. There was a decrease in SAR with tile drain water alone. Apart from some lime dissolution, Ca^{2+} in irrigation water also contributed in SAR decrease in this treatment.

Table 2. Effect of reclamation treatments on SAR of the saline-sodic soil after growing six crops

Treatment	Soil depth (cm)					
	0-15	15-30	30-60	60-90	90-120	Mean
			Original soil (May 1993)			
Tile drain water	60.8	23.2	23.7	19.8	14.8	28.5
Gypsum	77.5	26.1	25.0	17.5	13.8	32.0
Sulphuric acid	56.6	21.0	16.3	21.1	19.7	26.9
Farm yard manure	56.9	27.3	27.7	12.1	23.6	29.5
			After wheat harvest (May 1996)			
Tile drain water	20.7 (-66.0)	25.2 (+8.6)	14.3 (-39.7)	12.9 (-34.8)	12.4 (-16.2)	17.1 (-40.0)
Gypsum	27.5 (-64.5)	16.0 (-38.7)	9.4 (-62.4)	10.9 (-37.7)	8.7 (-37.0)	14.5 (-54.7)
Sulphuric acid	28.3 (-50.0)	19.5 (-7.1)	19.5 (+19.6)	8.1 (-61.6)	9.9 (-49.7)	17.1 (-36.4)
Farm yard manure	21.1 (-62.9)	11.6 (-57.5)	12.5 (-54.9)	11.6 (-4.1)	10.1 (-57.2)	13.4 (-53.9)
LSD	15.1^{NS}	11.7^{NS}	10.7^{NS}	6.0^{NS}	2.9*	2.7*

Figures in parenthesis indicate percent increase (+) or decrease (-) over the respective original SAR levels.
^{NS} = Non-significant * = Significant at $p < 0.05$.

3.3. Crop yield The first rice (*Oryza sativa* L.) crop during 1993 failed to yield except in some patches. The next rice crops yielded better than the 1993 crop. But the treatment differences remained nonsignificant and even the yields were not acceptable. This was due to the fact that the submergence requirement of the crop was not maintained because of high water intake rate after irrigation of the medium-textured soil with good drainage. Besides, the root-zone EC_e values remained higher (> 6.0 dS m^{-1}) than that at which 50% yield rėduction is expected (Aslam, 1987). However, soil SAR was not problematic for rice as earlier reported by Agarwal et al. (1964).

Wheat (*Triticum aestivum* L.) growth and yield were good throughout the study period (Table 3). The treatment effectiveness to produce wheat grain of the last crop was found in the order of FYM > gypsum > sulphuric acid > tile drain water. It appears convincing to include wheat as a winter crop during reclamation of medium-textured saline-sodic soils even using brackish water for irrigation.

Table 3. Growth response of rice and wheat crops to the reclamation treatments

Treatment	Grain yield (kg ha^{-1})					
	Rice (1993)	Wheat (1993-94)	Rice (1994)	Wheat (1994-95)	Rice (1995)	Wheat (1995-96)
Tile drain water	10	2854	602	2909	187	1100
Gypsum	11	2754	527	2697	166	1448
Sulphuric acid	12	2786	99	2828	191	1299
Farm yard manure	23	4188	381	4238	157	1861
LSD	8.2*	2238^{NS}	627.2^{NS}	2198^{NS}	73.2^{NS}	827.2^{NS}

^{NS} = Non-significant * = Significant at $p < 0.05$.

4. Conclusions

The brackish water, like the present one, can be used with soil application of gypsum or FYM for crop production and reclamation of calcareous saline-sodic soils. Rice was found to be an unsuitable crop on the medium-textured well-drained soil.

Acknowledgements

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Morphogenesis of Fodder Plants of the genus Astragalus

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Abstract – Two psammophilous Astragalus species A. kelifi Lipsky and A.flexus Fisch from Kyzylkum have been investigated. Both species are valuable fodder grasses of spring-summer vegetation. Both species are characterized by the short duration of a short life cycle which is completed in June; dying off of overground part of shoots; underground arrangement of residues which are longer in A.flexus and shorter in A.kelifi. The intensive organogeny provides the A.kelifi adaptation to the arid conditions and A.flexus has a large number of xeromorphic characteristic features.

Key Words: Leaf, shoot, internode, morphology, ontogeny

1. Introduction

Woody-shrubby and semi-shrubby desert plants Haloxylon aphyllum (Minkw.) Iljin, Kochia prostrata L. Schrad, Salsola orientalis S.G.Gmel, Halothamnus subaphyllus (C.A. Mey) Botsch and others are widely used for desert and semi-desert pasture reclamation (Allaniyazov and Tadzhimuratov, 1977; Momotov 1973). Technology to cultivation these species has been developed. It makes it possible to create high productive pastures of many years in the desert and semi-desert zones of Middle Asia; mainly for autumn and winter pasture of sheeps, goats, camels. But spring fattening on grazing is mainly due to grassy plants. Due attention has not been given to methods of grassy plant cultivation in gypsiferous desert. Successful work on Astragalus kelifi Lipsky cultivation has been carried out at the nursery of the Kyzylkum desert station (Momotov et al., 1989). It was revealed that vegetation of adult individuals begins in early spring and passes fairly rapidly. That is of great importance for sheep feeding when only ephemers are emerged. It was noted that high nutritiousness and mild stems in Astragalus species are not inferior to ephemers in nutritive quality. G.A. Baigozova (1987) studied Astragalus flexus Fisch in the sandy desert Taukuma. It was determined that the life time of each individual is 18-20 years. Published data on species morphogenesis and structure of vegetative and assimilative organs are absent.

2. Material and methods

Two Astragalus species have been studied. Astragalus kelifi Lipsky is endemic to Middle Asia. It grows in sands, in river valleys. Astragalus flexus Fisch is distributed in weak-fixed sands and is a good sand-fixer (Momotov, 1973).

Ontogeneral stages of seedlings and plants were fixed in 70% alcohol at the nursery of the Kyzylkum desert station. Methods were carried out according to Butnik et al. (1991)

Results.

Both species have epigeal plantules which appear in the first half or by the end of March. Cotyledons in A. kelifi are lamellar and oval in A. flexus. A cylindrical thick hypocotyl in A. kelifi is longer than in A. flexus. The root is also longer in A. kelifi than in A. flexus. A. kelifi has a rosetteless growth form of juvenile plants, A. flexus has rosette one, but sometimes rosetteless individuals are found (Table 1). The plantule stage in A.kelifi is shorter than in A.flexus. Two true leaves appear 5-7 days after germination. Tnen pinnate leaves begin to grow. By the end of May they are 18-20 cm long forming 7-10 pairs of leaflets. The juvenile stage lasts 1,5-2 months. By the end of June leaves dry up and vegetation is completed. By this time hibernating buds are formed and they start to grow. In A. flexus the juvenile stage lasts 14 months. 7-10 days after germination the first simple leaf appears, then 1 - 2 simple leaves appear followed by 4 - 6 three-compound leaves. By the end of May the

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TABLE 1

Bio-morphological characteristics of Astragalus species

Species		Astragalus kelifi	Astragalus flexus
Ecology edaphic factor		sands river valleys	sands
Biomorphe		W	R.-W.
Stages of ontogeny	P (days)	5 - 7	7 - 10
	J (months)	1,5 - 2	14
	Im (years)	2	2 - (4)
	G (years)	2	4 - (7)
Maximal life time, year		4 - 5	18 - 20
Length, cm	1-st order shoot	4 - 4,5 (12)	1, 5 - 8
	annual shoot	35 - 40	10-15 (20)
	residue	1,2 - 1,5	1 - 1,5 (2)
Percentage of annual shoots dying off		95	95
Number of metameres	1-st order shot	3 - 5	6 - 8
	annual shoot	20 - 22	6 - 8 (10)
	residue	7 - 8	3 - 4 (5)
Type of shoots		V, G	V, GS
Maximal depth of root system penetration		IV (35-45) см	IV (1,5-2) m
Presence (+) or absence (-) of vegetative reproduction		–	+
Length, mm / Width, mm	cotyledon	9/12 4/5	6/9 3/4
	leaves	6/9 6/8	6/15 (18) 8/11
Length, cm	hypocotyl	20-25 15-20	30-40 25-35
	root	30-40 25-35	25 - 35

Note: W – without rosette (rosetteless); R – rosette;
GS – generative specialised; V – vegetative.

cotyledons and the first 1-2 leaves fall off. Other leaves dry in a week. At the end of June plants fall into a dormant state. In A.kelifi the immature stage begins on the 2-nd year of vegetation, rosulate pinnate leaves (5-6) appear at the end of March. Axillary buds start their growth producing 3-5 shoots of the 2-nd order. Later on rapid shoot growth (2-2,5 cm per a day) is observed.

In A.flexus the immature stage begins in spring of the 2nd - 4th vegetative year. Axillary buds formed in summer of the previous year produce 1-3 short vegetative shoots with 6-8 imparipinnate leaves. Horizontal rhyzomes are formed underground. Plants come into the generative stage on the 4th year forming 8-10 pinnate leaves and 2-4 specialized generative shoots. In the sandy desert Taukuma the A.flexus generative stage begins on the 7th year of life (Baigozova,1987).

3.Conclusion.

Astragalus species differ in speed of vegetation. In A.kelifi vegetation proceeds more rapidly and on the 2nd year plants come into immature and generative stages of ontogeny. In A.flexus the immature stage begins on the 2nd–4th year of life, the generative stage in the 4th year.

In A.kelifi shoots are leafy and unspecialized. Generative flower buds are formed in the leaf axillaries. Lower parts of shoots are short metameric, higher parts are longmetameric, dying off up the level of 1-2 internodes. A.flexus has shoots of two types: short vegetative with short internodes and elongated specialized generative shoots. In A.kelifi the root system is superficial, in A.flexus rhizomes are the main root structures.

In its pattern of growth and development A.kelifi has features similar to ephemeroides. A.flexus has features similar to hemiephemeroidal rhizome main root herbaceous perennial plants.

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The Utilization and Development of Plant-Insecticides In Yuling Sand-land of China

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Abstract: This paper investigates three plant-insecticides, such as Amorpha fruticosa, and the controllable effect and practical result on major insect pests in Yuling sand-land. The rational way to disperse the plant-insecticides that is summarized.It considers that using the resources of the plant-insecticides may create an environment of stable sand fixation forest by means of controlling the insect pests in sand-land. The effective way of reducing chemical pesticide pollution is to develop vigorously the plant-insecticides. This paper points out that there are open vistas for developing the plant-insecticides in sand-land of the Northwest China.

Key words: plant-insecticides, Yuling sand-land, A. fruticosa, natural pesticides

The Yuling sand-land is located in the Northwest China.It is a part of Southeast of the Maowusu desert-land. Since the early days of the 80's, because of the population growth and the needs of economic development, the controlling of this sand-land is evidently quicken.The drift sand is gradually fixed. With the rapid increase of the covered rate of vegetation, the problem of insect pests become a factor more and more to affect the controlling effect. The controlling of chemical pesticide can make a trensient controllable effect,but fall into a new passive position in the couse of the implementation,that is just the environmental pollution. Happily, the nature has the function to continously progress regulation under the equilibrium law: Which have some natural plant-insecticides in the sandy vegetation. The resources of the plant-insecticides is used rationally, so as to bring into a bigger reaction play in the respect of controlling insect pests and harmonious developing the sandy controlling. That is a key to the question in sandy scientific controlling.

According to investigation,the Yuling sand have 11 Families 18 Species plant-insecticides (Table 1).Three plant-insecticides have been used on the daily production basis by the people,

Table 1: The main plant insecticides in Yuling sand-land

the name of plant	effective position	the name of plant	effictive position
Amorpha fruticosa L.	leaf and bud	Cynanchum hancockianum (Maxim) Al.Ujiaski	whole plant
Sophora alopecuroides L.	whole plant	Periploca sepium Bge.	whole plant
Thermopsis Laceolata R.Br.	whole plant	Calystegia hederacea Wall. ex. Roxb.	whole plant
Stilpnolepis centiflora (Maxim.)Urach.	stem and leaf	Sabina vulgaris Antoine	leaf
Inula salsoloides(Turcz.) Ostent.	leaf	Acorus calamus L.	whole plant
Xanthium sibiricum Patrin ex.Widd	leaf and stem	Wikstroemia chamatdaphne Meissn.	leaf
Euphorbia kozlovi Prough	whole plant	Stellera chamaejasme L.	whole plant
Ricinus communis L.	leaf	Chenopodium foetidum Schrad.	leaf and stem
Cicuta virosa L.	root and stem	Consolida ajacis (L.)Schur	whole plant

and it has become more recently sowing by plane in sand-land. As a insecticide, it not only applied gradually to the practice, but researched thoroughgoing its effective composition and controlling mechanism.

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1. The toxicity of three primary plant-insecticides

1.1. The toxicity

1.1.1.A. fruticosa. Except for the root the entire plant is effective in controlling insect pests. The effect of the leaves is the best. Its controlling effect reach 97.5 percent for the highly insect pest——the imago of Trematodes grandis (Table 2).

Table 2:the toxic effect of A. fruticosa for the sandy insect pests

The insects species	The death rate of testing group(per.)	The death rate of contrasting gruop(per.)	The rectified death rate(per.)
Trematodes grndis Semenov	97.5	0	97.5
Proagopcrlha Lucidula Faldermann	88.3	1.4	86.9
Anomala mongolica Faldermann	85.3	0	85.3
Diglosslrox alashanicus Suvrov.	86.5	1.5	85.0
Odosomus parallelocollk Heller.	82.4	0	82.4
Maladera orientalis Motschulsky	73.4	0	73.4
Plagiodera versicolera Laichart	62.9	0.5	62.4

Remarks: The test is gauze covered outdoors. They are fed on fresh leaves, calculation of the death rate after 36 hours.

1.1.2.C. hancockianum. The entire plant has a toxic effect (Table 3).

Table 3: The toxic effect of C. hancockianum for the sandy insest pests

The insects species	The death rate of testing group (per.)	The death rate of contrasting group(per.)	The rectified death rate (per.)
Hylemyia tloraris(Fallen.)	96.5	0.5	96.48
H.platura Meigen.	94.5	1.5	94.42
Musca domestica L.	91.0	0	91.0
Agrotis ypsilon Rottemberg	72.1	0.5	71.86
Stiboropustla idus Signoret	90.5	2.0	90.31

Remarks: The counting time of A. ypsilon is 12 hours, the S. idus is 72 hours.

1.1.3.S. vulgaris. The entire plant has toxcity; the effect of leaves is the highest. Its effect is 72.8 percent for Apocheima cinerarius, 70 percent for Cnaphalocrocis medinalis, and it has obvious effect for various kinds of Aphid. In addition, its leaves be chopped directly, then cast in manure pit, after 48 hours, the death rate can reach 84.4 percent for the larva of H. platura.

1.2. The pathological activity

The activity of A. fruticosa has the effect of a stomach poison. Using its fresh leaves to feed the imago of T. grandis. The contrast is the leaves of Hedysarum scoparium (a sandy plant). The test group experienced 100 percent anaesthesia and toxicity (within 1 hour), but they recover. After anaesthesia is repeated for three days, the tested insects will die because they can't take the food.

The effect of C. hancockianum is that of a contact and stomach insecticide.

The effect of S. vulgaris is that of a stomach poison and fumigant.

2. The used way and effect of controlling in sand-land

2.1. The bright choice of plant administer

Through effective insect control in Yuling sand-land over 20 years, the cover rate of vegetation has increased by 30 percent in these exposed drafting sands.In order to deal with the insect pests, local people did not hesitate to use chemical pesticides to control the raging insect pests over a great area. The researcher has gradually attached importance to these influence of the ecosystem's balance. From the middle and late the 80's, through systematic study and practice in a small area, the plant-insecticides began to be used to control the sandy insect pests in greater areas.

2.2. The applied way

2.2.1. The plant insecticide is mixed for sowing in the afforestation of fixed sand. A. fruticosa the main plant of fixed sand are mixed and sowed with a particular proportion (according to the different insect pests) in sand-land. When they are at most used way that apply the plane to sow the strengthen-sand plant with plant-insecticides, they will bring into effect of the sand-fixation and controlling insect pests play.

2.2.2. A means of increasing toxic effect
A. fruticosa is cut down every 4 to 5 years to increase its toxic effect.

2.2.3. The maceration extract is poured on the soil to control the insect pests
C. hancockianum and S. vulgaris's leaves after being chopped are soaked in water (the proportion is 1:5) for 24 hours and filtered. The filtrate is used to irrigate the protected plant. This is commonly used to control H. platura in vegetable fields.

2.2.4. Apply chemical way to extract the effictive composition
After maceration and effective chemical method is to soak with an organic solvent and extract the effective chemicals. Then dilute, emulsify and spray. We are using A. fruticosa as a raw material to test the commercial extraction in Yuling sand-land.

2.3. The controlling efficiency in large areas

2.3.1. Through to intergrow A. fruticosa on the plane-seeding-area, this plant may bring into the efficiency of controlling pests and protecting seedline play. Using this way, Hedysorum mongolicum and H. scoparium have been protected 2000 hectares. The investigative results indicated that they have all better effect with different form to intergrow A. fruticosa (Table 4).

Table 4: The efficiency of intergrowing A. fruticosa in large areas(1992)

the seeding form	The proportion of seeding and protecting area	the quantity of investigation steedlings	the quantity of death seedlings	The death rate of seedlings (per.)	The controlling effect (per)
seeding on every other line	1:1	761	6	0.7	96.6
the contrast		826	169	20.5	
seeding in sand-land	1:5	594	31	5.2	74.8
the contrast		635	131	20.6	
seeding on every other area on the slope of facing wind	1:10	549	14	2.6	83.5
the contrast		532	84	15.8	
seeding on every other area on the slope of lee side	1:15	738	10	1.4	94.2
the contrast		686	167	24.3	
circle wise transplant	1:20	962	12	1.3	93.8
the contrast		1104	233	21.1	

2.3.2. The controlling effect of intergrowing C. hancockianum
In the sandy grain crops, such as wheat and millet are being seriously attacked by S. idus. In recent years, C. hancockianum is continuously applied to control this insect by way of

mixed sowing、intergrow on every other area and rotation of crops, after adopting the different form to intergrow C.hancockianum, the insect pests is basically controlled, the insect density is greatly reduced, because there was a build up of a natural preservation zone of S. vulgaris in the 80's. Its natural forests have rapid development, and is promoted by controlling insect pests in the forest region and forestry sand. The density of the main insect pests and the harmed degree often remain a below economic level.

3. The applied range and the developing tendency

The area of A. fruticosa as a means of controlling insect pests and protecting seedlings has developed from 2000 hectares to 120000 hectares from the year of 1988 to 1996. The area of S. vulgaris has developed 8000 hectares in the natural preservation zone. The forests are expanding year after year in Yuling's floating sand.

In Yuling sand-land,the plant-insecticides is applied on a large-scale. The use of plant-insecticides has developed rapidly. In recent ten years, the usable volume of chemical pesticide is being constantly reduced to control the vegetable insect pests (Table 5).

Table 5:The situation of pesticide for the plant of fixed sand from the year of 1988 to 1996

the year	the utilized quantity of pesticide(ton) Phosphate pesticide / Total pesticide	the using way	remarks
1988	17.50/19.80	use plane,man-made	in great area
1990	9.76/12.96	use plane,man-made	in great area
1992	2.14/4.22	man-made	great place
1994	0.34/0.71	man-made	fragmentary region
1996	0.13/0.33	man-made	fragmentary region

4. The conclusion

4.1. The area grows some plant-insecticides of great value for the Yuling sand-land region (such as A. fruticosa、C.hancockianum、S.vulgaris). It is a precious resource of plant-insecticides. As the sand-land is further controlled, the scientific utilization of the plant insecticide will promote vegetable production and stabilize development of the sandy ecosystem.

4.2. Through techniques utilizing the plant-insecticides with mixed sowing and intergrowing in Yuling sand-land; stable、harmonious and long-term protected environment will be achieved by the control of insect pests.This will efficiently reduce the disturbance and artificial activities for sandy vegetation and the dependence for chemical pesticide.

4.3. While growing the plant insecticide, we must vigorously increase its strains and vigorously develop the commercial collection of the effective composition to reduce the environmental pollution.Adopting the methods of independent utilization or mixed utilization with a little chemical pesticide, such as A. fruticosa may produce the desired result.

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Micromycetes of Desert Plants in the Kyzylkum

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Abstract: Recently theoretical and practical studies of micromycetes have attracted the attention of specialists in different fields of industry. But the development of studies of micromycetes in our republic is hampered by the absence of the total and regional floristic reports which reflect the level of modern knowledge on species composition and micromycete distribution. A knowledge of species composition of micromycetes, their ecological and biological peculiarities and "centers" of infection, would aid in the preparation of recommendations for the control of phytopatogenic species. Furthermore, this information would permit forecasting of disease development in various regions depending on meteorological conditions.Prior to our work there had been no specific investigations on micromycetes in the Kyzylkum. Some earlier data is recorded in the work of N.G. Zaprometov (1926,1928), P.N. Golovin (1941) and Gaponenko (1965). For 1989-1994 we carried out research expeditions all over the Kyzylkum territory to study the species composition, distribution, biology and ecology of the desert plant micromycetes. This paper outlines our findings.

Key words: micromycetes, subdivision, class, order, family

1. Introduction

Nearly 80 per cent of the pasturelands of Uzbekistan are concentrated in the Kyzylkum desert. Their increased productivity would promote an increase in the productivity of cattle breeding in the republic. Timely control of diseases which decrease the yields of fodder plants would play an important role in the solution of this problem. Preventive measures are known to be a decisive factor in disease control. They are based on scientific forecasting, i.e. knowledge of species composition of pathogenic fungi, their selective relationship to nutrient supplying plants and environmental factors. The study of micromycetes in the arid zone of the Kyzylkum has investigated various habitats: plains, remnant hills, submontane plains, sands, tugai , salt - marshes and oases. Plains occupy the greater part of the desert. Shrub ahd semishrub vegetation is characteristic of them dominated by Artemisia diffusa H.Krasch., Astragalus L., Convulvulus L.. Sands cover huge areas in the Kyzylkum, mainly in its northern, southern and western parts. Woody-shrub psammophytes occur there. Formation Salsoleta gammascensae predominates in the salt-marshes. Tugai are connected with depressions.

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Formation Tamariceta hispidae occur in the regions with shellow groud waters and numerous springs. Oases occupy a comparatively small part of the arid zone, and are given to the principal crops: cotton, lucerne, cereals and melons. There are few orchards there. The main aim was to determine species composition of fungi; to give ecological and floristic analysis, i.e. to reveale distribution of fungi by nutrient supplying plants, by the vertical belts and by the seasons; to distinguish species of fungi which are of practical importance. 370 species of micromycetes have been recorded for the arid zone in the Kyzylkum, 220 of them are phytopathogenic species 10 species are the new records for the flora in Uzbekistan.

2. Methodology

Herbarium material has been collected by route and stationary method. Phenological observations were carried out by seasons. Pathogenic fungi which cause withering, putrefaction, cause damage to same fodder and cultural plants have been isolated into a pure culture in the laboratory according to Naumov (1953).

3. Results

As a result of our investigation and by the published data 370 species of micromycetes belonging to 109 genera, 16 ordes and 30 families have been recorded for 263 species of higher plants.

Table 1. Systematis composition of micromycetes in the Kyzylkum arid zones

Subdivision	Class	Order	Family	Number genera	species
1	2	3	4	5	6
Ascomycotina	Plectomycetes	Erysiphales	Erysiphaceae	7	35
		Eurotiales	Gymnascaceae	1	2
			Thermoacaceae	1	1
			Eurotiaceae	2	2
			Pseudeurotia-ceae	1	1
	Pyrenomy-cetes	Sphaeriales	Melanospora-ceae	2	5
			Sphaeriaceae	2	2
			Polystigmata-ceae	1	1
			Sordariaceae	1	1
			Diaportaceae	1	1
			Amphisphaeria ceae	1	1
			Xylariaceae	1	1
	Loculoascomy cetes	Dothideales	Dodhideaceae	2	4

		Pleosporales	Pleosporaceae	7	31
	Discomycetes	Pezizales	Morchelilaceae	1	1
			Helveliaceae	1	2
1	2	3	4	5	6
			Pyrenemata-ceae	2	2
		Helotiales		1	1
Basidiomycotina	Teliomycetes	Uredinales	Melampsora-ceae	1	4
		Ustilaginales	Ustilaginaceae	6	14
			Pucciniaceae	3	41
		Aphyllopho-rales	Polyporaceae	2	2
			Hymenochae-taceae	1	1
		Agaricales	Agaricaceae	4	6
			Coprinaceae	1	1
			Strophariaceae	2	2
Deuteromycotina	Hyphomycetes	Hyphomy-cetales	Moniciliaceae	9	19
			Dematiaceae	18	43
		Agonomy-cetales	Agonomyce-taceae	5	8
		Tubercula-riales	Tuberculaira-ceae	1	3
	Goelomycetes	Melanco-niales	Melanconia-ceae	4	12
		Sphaeropsi-diales	Sphaeropsida-ceae	18	121
Total : 3	7	16	30	109	370

Quantitative distribution of micromycetes taxa ia as : Ascomycotina - 4 classes, 7 ordes, 18 families, 34 genera, 93 species; Basidiomycotina - 1 class, 4 order, 8 families, 20 genera, 71 species; Deuteromycotina - 2 classes, 5 ordes, 6 families, 55 genera, 206 species. By the number of species and area of distribution the representatives of Deuteromycotina and Ascomycotina predominate and represent the basic background in the Kyzylkum. Under the severe climatic conditions of the arid zones they survive due to their drought and cold resistance.
Table 1 shows that Ascomycotina is represented by 4 classes: Plectomycetes, Pyrenomycetes, Loculomycetes, Discomycetes. The majority of species in the subdivision Ascomycotina , belong to the class Plectomycetes (42) and Loculoascomycetes (35); the other classes include 2-5 species each. Erysiphales

are widely distributed in the arid zones of the Kyzylkum desert (35 species).

Settling on natural plants they cause significant yield decrease in lucerna, pumpkin,, melon and mulberry. Widespread species of this order are Leveillula le guminosarum, Sphaerotheca fuliginea, S. pannosa, Phylloctinia moricola, Trichocladia astragali, Erysiphe raminis. Order Pleosporsles of the class Loculoascomycetes has the largest number of species (31). The family with the highest number of species is Pleosporaceae with genera Lophiostoma, Mycosphaerella, Pleospora. Many species of Ascomycotina are new record for the Kyzylkum. They are Didymosphaeria brunneola Niessl., D. lycii (Kalchbr) Sacc., Pleospora pellita (Fr) Rab., Pl. statices Lab., Pl. spinosella Rehm., Pl. heliotropii Golov., Pl. anabasicis Gopon., Pl. comata Auersw., Lertosphaerulina briosiana (Poll.) Graham and Lutter., L. convolvuli (Kalym.) Byzova.

Under the arid conditions of the Kyzylkum desert regular distribution of the representatives of subdivision Ascomycotina has not been observed. Only light-coloured forms are frequently met in tugai. Frequently met species Pleospora herbarum, Pl. vuigaris, Trematosphaeria mastoidea are attributed to typical fungi.

Within Subdivision Basidiomycotina the families Ustilaginaceae (14 species) and Pucciniaceae (41 species) have the largest number species. The representatives of the other families are also rather typical to arid zone, and are found as freaquently as rusts. In particular, smuts and gasteromycetes are widespread in the Kyzylkum desert. Early in spring when ephemers and ephemeroids develop in the desert they are infected by the fungi of the denes Hyphomycetes; shrubs and semi-shrubs are infected by the fungi of the genes Coelomycetes. In summer marked recession in the development of all fungus groups is observed and only the representatives of Erysiphaceae reaches their highest distribution on fodder, vegetable and melon crops. Imperfect fungi Deuteromycotina makes up over 50% of the total mycoflora in the Kyzylkum, including the 2 classes Hyphomycetes and Coelomycetes, 5 orders, 2 families, 55 genera and 206 species of which order Sphaeropsidalesis represented the largest number of genera and spesies (121species). Genera Coniothyrium, Phoma, Hendersonia, Diplodia are widely spread, then come families Dematiaceae, Moniliaceae, Meloncoliaceae.Though being represented by less number of species (12) they have the greatest frequency of occurence. Semiparasitik species of the genera Camarosporium and Steganosporium are widely dispersed on the plants edificators. Imperfect fungi developed on 182 species of higher plants. Leguminous plants are infected by the largest number of fungi (12 species), then come cereal plants (5-6 species). 81 fungus species have been found in the plains, 48 in submontane plains, 46 in remnant hills, 44 in oases, 42 in sands, 32 in salt-marshes and 27 in tugai.

Table 2. Distribution of micromycetes in the Kyzylkum

Location	Number of species	Speciea characteristics	Specifis important genera
Plains	81	Moniliaceae, Sphaero-	Steganospora, Phoma,

		psidaceae	Ustilago
Submontane plains	48	Pucciniaceae,Ustilagina-ceae, Sphaeropsidaceae	Septoria, Puccinia
Remnant hills	46	Pleosporaceae,Erysipha-ceae,Sphaeropsidaceae	Pleospora, Trichocladia, Diplodia
Oases	44	Erysiphaceae, Monilia-ceae, Tuberculariaceae	Sphaerotheca, Fusari-um, Ovularia
Sands	42	Erysiphaceae, Sphaero-psidaceae, Agaricaceae	Leveillula, Agaricus
Salt marshes	32	Melanconiaceae, Sphae-ropsidaceae	Coniothyrium, Camaro-sporium, Gloesporium
Tugai	27	Moniliaceae, Agarica-ceae	Ramularia, Agaricus, Pholiota

Pycnidial fungi dominate in plains, hyphal fungi in oases, melancolnial in sands. Species of genera Coniothyrium, Camarosporium, Septoria, Phoma, Hendersonia, Diplodia, Steganosporium and Cladosporium are distributed everywhere. Species of genera Septoria and Ascohyta are frequently met under mesophilic conditions, while Coniothyrium are found in typical desert locations. Streng-thening of pathogenity of a number of necrotrophic fungi as Gloesporium ampelinum (de Bary) Lacz., Gloesporium veronicar (Lib.) Karav., Cylindro-sporium Rhei Murashk., Alternaria tennuis Nees. is observed. Apparently, changes in pathogenity are connected with changes occuring under the influence of hosts and climatic conditions. It is not excepted that these changes are conditioned by the appearance of new more pathogenic forms and races. Analysis of species composition of micromycetes in the arid zones of research area showed that their distribution is determined by their position in the desert zone with altitudinal zonation.

5. Conclusion

The completed work on investigation of micromycetes in the arid zone of the Kyzylkum is a part of studies of fungal flora in Uzbekistan. The ultimate end is the publication of " Flora of Parasitic Fungi of Fodder and Cultural Plants " in many volumes and the preparation of recommendations on preventive measures against harmful fungus species.

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An Ecological Small Oasis in the Heartland of the Taklimakan Desert

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Abstract - There were hardly any lives before the experiment in the heartland of the Taklimakan Desert. So far, 3 ha of ESO have been built since 1994, including 2.0 ha reed straw paling and reed straw checherboard square, 0.6 ha shrub land, 0.2 ha grassland, 0.1 ha flower land, 0.06 ha field vegetable and 0.04 ha greenhouse vegetable. 183 plant species have been introduced , and the result is that 48 species can grow well in the harsh environment. The average height of shrub and grass is 0.8 m and 0.3 m respectively. The greatest success is that the annual yield of vegetables in greenhouses is more than 114 tones per ha and the annual yields of vegetable in field reach 30 tones per ha.

Key word: Oasis Desert Heartland

1. Introduction

The Taklimakan Desert is the second biggest moving desert in the world. The ecological small oasis (ESO) was set the heartland of the Taklamakan Desert: the east longitude 83 ° 36.4', north latitude 39 ° 01' , and 1145m above sea level. The distances were 230 km and 290 km respectively from the south and north edges of the Taklimakan Desert. The annual precipitation is less than 50 mm, but the annual evapotranspiration is 3051 mm being 71.7 times the precipitation. The annual average air relative humidity is 44%. Especially, the air relative humidity is below 20%.

The annual sunshine is 2737 hours. The annual total radiation is more than 570 kj/cm^2. The period of frost is about 121 days. The average air temperature is 11.5 ℃, and the highest air temperature reaches 43.5 ℃. In contrast , the lowest air temperature is minus 23.9 ℃.

The annual average wind speed is 2.3 m/s. The highest wind speed is 17.2 m/s. The dominant wind direction is NE. Storms with fine sand and dust occur for 31 days and 80 days per year respectively. The total transported amount of sand exceeds 6000 tones per year per kilometre.

The bulk density of the soil is 1.49 ~ 1.54 g/cm^3. The capacity of holding water and fertilizer is poor. The content of organic matter of the soil is less than 0.9 gram per kilogram dry soil. N, P and K are very deficient.

Ground water is the only resource of water. The depth of the ground water is 1m to 10m. The water is saline with a salt content of 4.50 ~ 4.80 g/l. Moreover, the main chemical components are Na^+1.11g/l, Cl^- 1.74g/l, $SO4^{2-}$ 1.06g/l, they all exceed the limiting value that plants can tolerate. However, as a result of the experiment, the ground water can be used to irrigate plants because of the good infiltration of the wind blown sand.

The sand dunes surround the ESO. Plants did not exist on sand dunes before the ESO was established in 1994.

2. The construction of the ESO

The ecological small oasis was built in order to protect the basement of exploring oil in the Taklimakan Desert. Protection Sub-system, Production Sub-system and Consumption Sub-system comprise the basic construction of the ESO system (Fig 1). The protection sub-system prevents

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windy and sandy storms from harming other sub-systems. Such an approach is crificalin the desert environment in the heartland of the Taklimakan Desert.

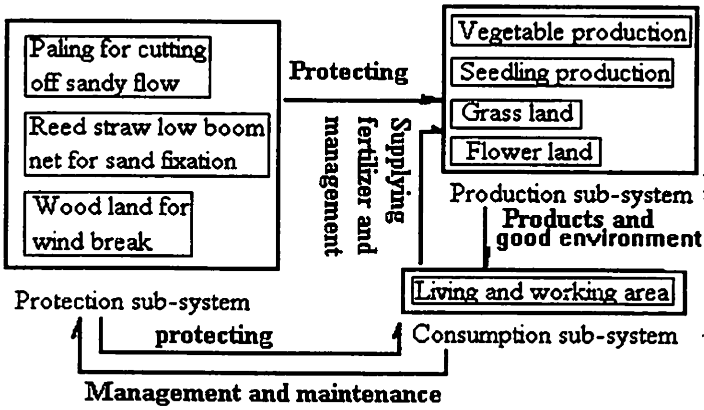

Fig. 1: The basic construction of ESO System

3. The building of the ESO in the heartland of Taklimakan Desert

A Forest Experiment Station in the heartland of the Taklimakan Desert was established in 1994. One ecological small oasis was built up after 2 years.

3.1 Making the protection sub-system Two rows' reed straw palings: height 1.2 to 1.3 m and separation 10m. The length per unit paling is 3.0 m. The height of the paling above surface of sand dune is 1.0 m, and the paling is buried under sand 0.2 to 0.3 m (Fig. 2). Many units of paling are connected by wooden stakes to meet the need for protecting. The paling can cut off the sandy flow and keep sand outside the small oasis. Reed palings whose height and density can change according to height of plants protected.

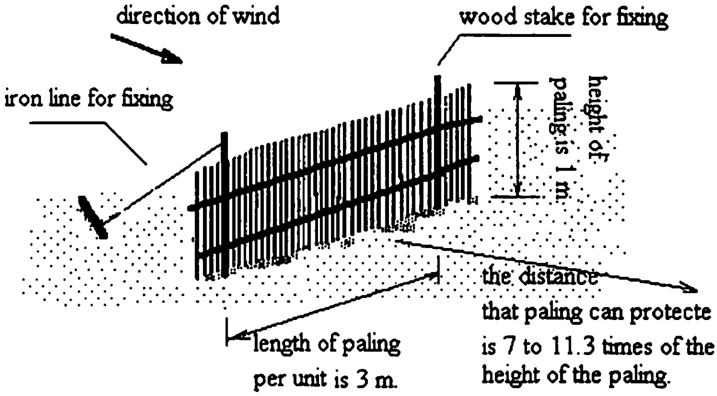

Fig. 2: The reed straw paling for cutting off sandy flow

Reed straw checkerboard square: length and width per square 1.0 m, and the height above surface of sand dune is 15 cm to 20 cm. In addition, the depth buried under sand is 10 cm to 15 cm. The reed straw square lattice is made to reduce the amount of sand with wind and to stop the movement of dune. The total width of the reed straw checkerboard square is 30m.

Plants for stabilising the sand dune are selected through an introduction test. The total width of the wood land is 10 m to 15 m.

3.2 Building salt water irrigation system The ground water is used to irrigate plants. Small border irrigation is used for shrub and small arbor, and drip irrigation is utilized for fruit tree and vegetable.

3.3 Experimentatoin to introduce plants The experiment station introduced 183 plant species in order to find some that could survive the harsh environment. 48 species were suited to the environment.

55 species (14 families) were introduced to stabilise the sand dune. The following species grew well in the desert environment : Tamarisk family (13 species) (*Tamarix taklamakanensis M. T. Liu ; T. ramosissma Ledeb ; T. hohenackeri Bge.; T. hispida willd ; T. karelinii Bge.; T. leptostachys Bge.; T. elongata Ledeb ; T. sp.; T. androssowii Litv.; T. chinensis Lour.; T. kansuensis H.Z.Zhang ; T. austromongolica Nakai ; T. laxa willd*), Calligonum family (4 species)(*klementzii A. Los.*), Caspian Sea Karelinia(*Karelinia caspiea (Pall.) Less.),* Hexi Cineraria *(Hexinia polydichotoma (Ostenf.) H.L.Yang),* Licorice(*Glycyrrhiza infolata Bat.*), Alhagi Mannaplant (*Alhagi pseudalhagiDesv.*), Threeawngrass (*Aristida grandiglum Rosher*), Ravennagrass (*Erianthus ravennae (L.) Beaur*), Clustered Halogeton (2 species) (*Hologeton glomeratus* (Bieb.) *C.A.Mey.*; *H. arachnoideus Moq.*), Divaricate Bassia (*Bassia dasyphylla (Fisch ex Mey) Kuntze*), Saxoul (*Haloxylon ammodendron (Mey.) Bunge*), Persican Saxoul (*Haloxylon persicum Bunge ex Boiss et Buhse*), Bloomy Poplar (*Populus pruinosa schrenh*), White Elm (*Ulmus laevis Pall.*), Russianolive (*Elaeagnus angustifolia L.*), Common Reed (*Phragmites communis Trin*).

22 species of grasses for improving the environment were introduced. Perennial Ryegrass (*Lolium perennis L.*), Annual Bluegrass (*Poa annua L.*), Intermediate Elytrigia (*Elytrigia intermedia* (*Host*) *Nevski*), Ternateleaf Rabdosia (*Rabdosia ternifolia* (D. Don) *hara*) and Alfalfa (*Medicgo safiva L.*), were suitable for the environment.

57 pecies of flowers were introduced. Linearleaf Inula (*Inula peariifolia Turcz.*); Kansu Jasmine (*Jasminum humile var. kansuense Kobuski*); Aztec Marigold (*Tagetes erecta L.*) and Hollyhock (*Althaea rosea* (*L.*) *Cavan.*), tolerated the harsh environment.

Five field crop species (30 varieties) were introduced. Bachun No.4 (wheat) and Junmian No.1 (cotton) could normally grow in the environment.

37 species of vegetables were introduced (Chen, et al, 1995). Planting Asparagus (*Asparagu officinalis var. altilis L.*); Celery (*Apium graveolens*); Summer Squash (*Cucurbita pepo L.*); Muskmelon (*Cucumis melo L.*); Tomato (*Lycopersicon esculentum Mill.*); Pepper (*Capsicum fruteslens L.);* Eggplant (*solanum melongena L.*); Spinach (*Spinacia oleracea L.*) and Pakchoi (*Brassica chinensis L.*). Good quality products and high yield were gained.

.2.4 Making the small oasis Small arbors are planted and north wall of greenhouse is located at north and north-east of small oasis because the main wind direction is NE, then shrubs are planted. Flowers, grasses and vegetables can be cultivated at middle, south and west of the small oasis.

The culture techniques are very important for all plants because of irrigating salt water. Methods as follows can be used after the test for two years has shown: (1) transplanting culture; (2) much more overrotten organic matter; (3) dressing is a little repeated many times; (4) combining drip irrigation and flood irrigation to prevent salt injury; (5) balancing the vegetative growth and irrigation and flood irrigation to prevent salt injury; (5) balancing the vegetative growth and reproductive growth by careful management.

Greenland has finished for 1 hm^2 in 1995, including 0.6 hm^2 shrub land, 0.2 hm^2 grassland, 0.1 hm^2 flower land, 0.06 hm^2 field vegetable and 0.04 hm^2 greenhouse vegetable.

4. The effects of the ESO

4.1 The effects of the protection sub-system The reed straw paling reduces the transportation amount of sand into ESO for 97.4%, and it can prevent that the sand is shifted by wind within the distance that is 7.0 to 11.3 times of the highness of the paling (in Fig 2).

The reed straw checkerboard square can reduce the wind speed at surface of the sand dune for 60% to 80%. The transportation amount of sand with wind can also reduce for 99%.

The wood land (wind break forest or shelterbelt) can reduce the wind speed for 30% to 40%.

The result is very good when the reed straw paling , reed straw checkerboard square lattice and wood land are combined to use in the protection sub-system. The wind speed at center of the small oasis is lower than 2 m/s while the wind speed outside the small oasis is 10 m/s. Moreover, the sandy and windy storms are not possible to happen within the small oasis. Therefore, plants in the small oasis are not damaged by sandy or windy storm.

4.2 The effects of the production sub-system Seedlings have been bred in 1995, they can be used to build up new wood land.

The yields of vegetables in greenhouse exceed 114 tons per hm^2 per year per year (table). The highest yield reaches 227 tons per hm^2 per year. The economic profits are over 270,000 Chinese Yuan per hm^2 per year (about U.S.$ 32,900).

Vegetables can only be cultivated one time per year in field because the climate is very harsh. The yields of vegetables reach 30 tons per hm^2 per year.

Table: The yields of vegetable in greenhouse (tons per hm^2 per year)

culture method	tomato and celery	tomato and tomato	tomato and green Chinese onion	Pakchoi and egg-plant and Pakchoi	tomato and summer squash
yield	177.2	150.8	139.4	151.5	114.4

4.3 The changes of the environment factors The daily highest air temperature is 2 ℃ lower in the ESO than in sand dune, but the daily lowest air temperatures have not any distinguish. The daily average air relative humidity raises up about 3%. In addition, the daily soil temperature range reduces about 10 ℃ in the ESO.

Furthermore, the ecological system is also improving, birds, dragonfly and worm have enjoyed this system. Indeed, the living environment is improving, and we are sure that is very good for health of workers.

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An Evaluation of the Plant Resources and Diversity of *Tamaricaceae* in China

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Abstract- There are 3 genera, 32 species and 2 varieties of *Tamaricaceae*, 50% of which are rare and endemic species in China mainly occurring in the arid and semi-arid regions. From Northwest to Southeast, the species diversity decreases progressively. Himalayia area and Xinjiang are respectively the originating and distributing centers of *Myricaria* and *Tamarix* in China. Varieties of geographical environment, climate, habitat and biological characteristics of species bring about the genetic diversity of *Tamaricaceae*. In this paper, the economical value and significance of ecological environment and scientific research of the plant resource are discussed.

Key words: *Tamaricaceae*, Plant resources, Biodiversity Evaluation

1. Resources of species diversity

Tamaricaceae are shrubs, subshrubs or dwarf true trees. There are 3 genera and over 120 species of *Tamaricaceae* plants, mainly existing in the old world age steppe and desert regions, of Asia, southern Europe and northern Africa. There are 3 genera, 32 species and 2 varieties of *Tamaricaceae* plant in China. *Reaumuria L.* are subshrubs or shrubs. There are approximately 12 species in the world (4 species in China), mainly found in Asia, southern Europe and northern Africa. *Tamarix L.* are shrubs or dwarf true trees. There are 90 species in the world, mainly occurring in the arid and semi-arid regions of Asia, northern Africa, Europe and the western coast of Africa. There are 18 species and 1 variety of *Tamarix* in China, mainly found in northwestern China, Inner Mongolia and northern China. *Myricaria Desv.* are deciduous shrubs or subshrubs. There are 13 species of *Myricaria* in the world (10 species, 1 variety in China), mainly occurring in Asia and Europe. Most *Tamaricaceae* in China are found in desert and semi-desert regions in northwestern provinces, especially in Xinjiang, Gansu, Inner Mongolia, Qinghai and Ningxia provinces (73.5% in Xinjiang, 58.8% in Gansu, 47.7% in Inner Mongolia, 47.1% in Qinghai and 41.2 % in Ningxia). From northwest to southeast, the species diversity of *Tamaricaceae* in China decreases progressively. There are 16 species of *Tamarix* in Xinjiang (84.2% in China). Particular climate, soil and hydrology provide suitable conditions for the migration and spread of *Tamarix* in Xinjiang and Xinjiang becomes the region of the most abundance for *Tamarix* species diversity in China because of abundant plant resources, richness of species and large area of distribution. There are 4 species of *Reaumuria* in China, also in Xinjiang. Most *Myricaria* species exist in the Himalayan region and areas close to it which lie on the Qinghai-Xizang plateau (8 species, 72.7% in China), so these areas form the origin and distribution center for *Myricaria Desv.*

Table 1 The species of *Tamaricaceae* in China and their distribution

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SPECIES	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	REMARKS
Myricaria elegans royle	√						√												
M. elegans var. tsetangensis P.Y.Zhang							√												endemic to Xizang
M. laxiflora P.Y.Zhang																√	√		endemic to China
M. paniculata P.Y.Zhang			√	√	√		√			√				√	√	√			endemic to China
M. platyphlla Maxim.		√	√		√														endemic to China
M. pulcherrima batal	√																		endemic to Xizang
M. rosea W.W. Sm.							√								√				
M. squamosa Desv.	√			√		√	√									√			
M. wardii Marquand							√												endemic to Xizang
M. bracteata royle	√	√	√	√	√	√	√	√						√					
M. prostrata Hook. F.	√			√		√	√												endemic to China
Reaumuria altenifolia Britt.	√																		endemic to Xinjiang
R. kaschgaria Rupr.	√			√		√	√												
R. trigyna Maxim.	√	√	√	√															endemic to Southern Alashan
R. songarica Maxim.	√	√	√	√		√												√	
Tamarix albiflonum M.T.Liu	√																		endemic to Xinjiang
T. androssowii Litw.	√	√	√	√															
T. arceuthoides Bunge	√			√															
T.austromogolica Nakai		√	√	√	√	√				√				√					endemic to China
T. chensis Lour.					√			√	√	√	√	√	√	√					endemic to China
T. elongata Ledeb.	√	√	√	√		√													
T. gansuensis H.Z.Zhang	√	√		√		√													endemic to middle Asia
T. gracilis Willd.	√	√		√		√													
T. hispida Willd.	√	√	√	√		√													
T. hohenackeri Bunge	√	√	√	√		√													
T. sachuensis P.Y.Zhang et M.T.Liu	√																		endemic to Xinjiang
T. jintaenia P.Y.Zhang				√															endemic to Gausu
T. karelinii Bunge	√	√		√		√													
T. laxa Willd.	√	√	√	√	√	√													
T. laxa Willd. Var. polystachya Bge.	√	√	√	√	√	√													
T. leptostachys Bunge	√	√	√	√		√													
T. ramosissima Ledeb.	√	√	√	√		√	√												

A. Xinjiang B. Inner Mongolia C. Ningxia D. Gansu E. Shanxi F. Qinghai G.Xizang
H. Hebei I. Liaoning J. Henan K. Shandong L. Jiangsu M. Anhui N. Sanxi

O. Yunnan P. Sichuan Q. Hubei R. west to northeastern China

2. Rare and Endemic Species

Tamaricaceae is an ancient family. There are 17 rare and endemic species of *Tamaricaceae* in China and 8 endemic species of *Tamarix* in China, 5 species in Xinjiang. There are 2 endemic species of *Reaumuria* in China, also in Xinjiang. There are 7 endemic species of *Myricaria* in China and 46% of them occur in Himalayan areas.

3. Genetic Diversity Resources

The flowers of *Tamaricaceae* are bisexual and its inflorescence is usually racemose with a large panicle. The plants are not only self-pollinating but also cross pollinating. This kind of pollination makes it possible for genetic exchange to occur between intraspecific individuals and intraspecific populations. This promotes *Tamaricaceae* genetic mutation with the intraspecific. There are *Tamaricaceae* populations consisting of mono-species in nature, such as *Reaumuria soongorica*, *Myricaria sp.* and *Tamarix taklamakanensis*. However, populations can also consist of 3 to 4 species. For example, *Tamarix hohenackeri* often exists with *T. ramosissima*, *T. arceuthoides*, *T. leptostachys* and *T. elongata*. *T. ramosissima* often exists with *T. leptostachys*, *T. elongata*, *T. hispida* and *T. karelinii*. Not only florescence of interspecies are close or overlap, but also these species exist in same habitat, So it is easy to occur hybridization between these species, series of hybridization species and interspecies type were produced accordingly. *T. ramosissima* occurs world-wide. Its habitat is many and varied. Because of geographical isolation, genetic exchange in one population and hybridization with *T. hohenackeri*, *T. leptostachys* and *T. arceuthoides* in nature, there are varied interspecies and variation in species type within *T. ramosissima*. Populations of mono-species which exist in the same habitat sometimes contain 2 or more than 2 types of different characteristics, such as different colors of flower and fruit, different structure of flower. All of this constitutes pattern diversity within Tamarix. In order to study biological character, ecological character, population origin, system evolution and genetic diversity of *Tamaricaceae*, we need to adopt the technology of molecular biology, since this makes it possible to analyze the genetic variation within intraspecies, interspecies and subspecies.

4. Habitat Diversity

As for ecological adaptability, *Tamaricaceae* plants are almost omnipotent. They range from valley, gravel Gobi, oasis, alluvial-fan to Taklimaken desert and exist in varied soil types, such as sand soil, loam, salinization soil and topical saline soil. *T. ramosissima* is a cosmopolitan species because of its perfect adaptability. Some species are found only in one habitat, such as *T. taklamakanensis* which is only found in the hinterland of the Taklimaken desert, *T. hispida, T. laxa and T. karelinii* mainly occur in saline soil. *T. albiflonum, T. arceuthoides* and *T. tarimensis* are topical stenochoric. The distribution of *Tamaricaceae* is related to many ecological factors such as climate, rivers and the salt content of soil. *Reaumuria* is zonality vegetation, *Tamarix* and *Myricaria* are nonzonality vegetation. But in limited habitat, we can find out distribution pattern of *Tamaricaceae*. *Reaumuria* will replace *Myricaria* with the reducing of soil moisture in habitat. *Tamarix* occur from 120 meters below sea level to 3000 meters above sea level. *Myricaria* mainly occur in higher altitude regions, but *Reaumuria* and *Tamarix* mainly occur in middle altitude and low altitude regions. *Myricaria* exist in slightly salinized soil, but *Reaumuria* and *Tamarix* usually exist in saline soil.

5. Evaluation of Diversity Resources

5.1 Economic value. *Tamarix* are traditional medicines in China. In additional, it can be used for weaving material, building material, fodder, fuel and nectariferous plants etc.

5.2 Significance of ecological environment. There are not only zonality species but also nonzonality species in *Tamaricaceae*. This make it possible for us to select various species to fix shifting dunes in different habitats. *Tamarix* are arid and salt tolerant. Its roots are capable of producing adventitious buds. Adventitious roots are abundantly produced when the plant is buried by shifting dunes, and some species of *Tamarix* are therefore excellent dune binders. *Tamaricaceae* plants provide habitats for microbes, parasitic plants, insects, animals etc. The plant is an important link in the food chain of the desert ecological system because flowers, fruits, younger branches, roots, withered leaves of the *Tamaricaceae* plant are the food for animals, insects and microbes in the desert.

5.3 Value of scientific research. During the long period system evaluation, *Tamaricaceae* produced and accumulated abundant genes for resisting adverse circumstances. These are fine genes that human beings hope to harness and promote in cultivated plant. Using technology of genetic engineering, we can transform these fine genes to cultivated plant. In additional, *Tamaricaceae* is an ancient family. Based on studying system evolution of *Tamaricaceae*, we can reveal the process of form and evolution in flora in arid desert regions.

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Phisiologo-biochemical Investigations in Kyzylcum Desert Plants

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Abstrakt

Ivestigations of the ecogologo-phisiological and biochemical properties of wild plants in Kysylkum have been carried out. The aim of the investigations was to elucidate functional plant resistance to the extreme environmental conditions of the region. About 150 species of plants of landscape in South- Western Kyzylkum were characterized according to the ir physiologo-biochemical features. Great differentiation between species was determined by the functional adaptation to growing conditions. Characteristics desert plants which destinguish the m from plants of other geographical zones were revealed.

Keywords: Kysylcum,photosinthesis, respiration,.pigments. metabolism.

1. Introduction

In the Kyzylcum (Kyzylkum desert station'') for several years ecologophisiological and biochemical investigations of wild plants have been perfomed. They are directed towards understanding the functional resistance of plants to extreme conditions habitat. They provile a scientific basis for raising the productivity of pastures.

2. Results

As a result of long-term systematic stationary investigations about 150 species of desert plants were comprehensively characterised by their photosyntethic activity (photosynthetic intensity, pigment complexchrorophylls "a" and "b", carotinoids), respiration gaseous exchange, metabolism (carbohydrate. nitrogen. phosphorus , nuclein, protein).
Physiologo-biochemical peculiarities of desert plants which distinguish them from plants of other geographical zones were revealed. Wide range of temperature optima for photosyntesis is characteristic of desert plant. It is determined by plant belonging to one or another life form (Zakharyants et al..1971). The photosynthetic temperature optimum lies within the range of relatively low temperatures from 10-15 to 30°degree C in herbaceous plants with short period of vegetation (ephemers and ephemeroids) and

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" Kyzylkum desert station of the Institute of Botany Uzbek Academy of Sciencies is situated at the foot of the Kuldzhuktau mountains (south-western Kysylkum), 160 km to the north-west from Bukhara (latitude 40° 45'N, longitide63 45'E; 370-376 m above see-level).

from 15-20 to 35 degree C, from 25 to 40^{o},. from 15 to 45^{o} in shrubs and semishrubs (long-vegetating plants) depending on plant adaptation level. High resistance of photpsynthetic system to super-optimal temperature was observed. This feature is inherent to desert plants. High temperature (35-40 degree C for an hour) decrseaseas photosynthesis by 50% in ephemers : in shrubs, semi-shrubs and trees over 40-48 degree C. Low content of chlorophyll and high content of carotinoids is observed in comparison with plants of other geographical zones. The total chlorophyll content varies over a wide range- 0,33-3,6 mg/g. carotinoids - 0,16 - 0,75 mg/g raw mass. About 60 per cent of studied species contein chlorophyll within the limits 1 mg/g raw mass (Tadzhieva, 1975). The majority of plants with minimum chlorophyll content were determined to be main edificators of a desert. Hihg thermostability of photochemical activity of chloroplasts was determined. Its inactivation occurs within the range of super-optimal temperature from 50 to 55 degree C (Tadzhhieva, Rakhimov, 1977).

Large diversity of respiration rate values is observed in desert plants (110-600 $mm^3 O_2$ /g fresh weight per hour at 20-25 degree C). Critical respiration temperature wich characterizes resistance of respiration system to temperature is 40-45 degree C (Alekseeva, 1970):

Table I. Critical respiration temperatures in different forms of desert plants.

Life form	Number of studied species	Critical temperature, degree C
Ephemers	42	40-47
Annual grasses (salsolas)	12	50-52
shtrubs,semi-shrubs	7	45-54

Diversity of respiration responce in assimilating organs determined by the development cycle and biological peculiarities of speies to dehydration was revealed (Abdurkhmanov and Alekseeva, 1975).

Study of carbohydrate exchange in leaves of winter and spring vegetating plants (ephemers and ephemeroids) showed wide range of carbohydrate sum (12-60 % abs. dry weight). Over half of the studied plants have monosaccharide type of exchange (Azarova,1970).
The content and complement of carbohydrates is lower in shrubs and semi-shrubs than in ephemers and ephemeroids (Alekseeva, 1964; Sabirov,1975)

The presence of saccharose hemicellulose and pectine fractuons promote raising drought - resistance (Alekseeva , 1964 ; Sarirov, 1975).

Protein index (ratio of protein nitrogen to the total nitrogen) - 80-90%. Almost all amino acids of vegetable proteins have been found in free state in leaves of desret plants (Rustamov, 1975). A number of plants accumulate alanine and glutamine which apparently play protective role at drought period , enhancung, osmotic water retention.

Study of phosphorus exchange showed that the content of organic phosphorus in desert plants is very high and reaches up to 80-90% of total phosphorus higher that is higher than in cultivated plants (Nigmatov and Zakharyants,1980). The total content of phosphorus compounds in the desert plants is lower than in cultivated ones with the exception of early-vegetating grasses (ephemers and ephemeroids) which have hign content of phsphorus compouds. Slow metabolism is typical of shrubs, semi-shrubs and annual salsolasplants of long vegetation. Relationship of nuclein exchange with taxonomy of species was revealed (Nigmatov, 1980)

Table 2. Content of nucleic acid sum in desert plant leaves (mcg per lg abs. dry mass)

Life form / Family	Number of species	Ephemers	Epheme-roides	Perrenial herbaceou	Annual salsolas	Semi-shrubs, shrubs, trees
Fabaceae*	8	1520	-	1104	-	703
Cruciferae	12	1417	-	1464	-	-
Asteraceae	12	1340	1319	1285	-	802
Liliaceae	3	-	966	-	-	-
Poaceae	4	948	-	-	-	-
Umbelliferae	4	-	785	-	-	-
Zygophyllaceae	2	-	-	768	-	
Polygonaceae	2	-	-	-	-	703
Chenopodiaceae	21	-	-	-	650	388

High content of nucleic acids was found in species of families Fabaceae, Cruciferae, Asteraceae, the lowest-in Poaceae species, and in partcular in Chenopodiaceae. Among life forms the highest content of nucleic acids was

*/ Family numes acoccording to Takhtajan A. (1987)

determined in ephemers, the lowest in shrubs, semi-shrubs, annual salsolas.Water and alkalisoluble fractions of proteins (albumins and glutelins of the 2-d order) make the main part in protein exchange in desert plants during vegetation. A Characteristic feature of desert plant metabolism is resilience to water and temperature stress. This shows high level of adaptation to extreme conditions.

Studies physiology of wild desert plant seeds have been conducted (Ionesova,1970). The content of carbohydrates, proteins, oils, ashes, vitamins (C,E,P, group B and carotene), pigments was determined in seeds and fruits of desert plasnts. Different seed viability assays were applied, period of seed preservation and life time was determined. Highcontent of substances with vitamin P activity was revealed in desert plant seeds. These substances are mainly concentrated in seed egrets and increase in their guantity is observed during preservation. The reason for deterioration and total loss of germinability is suggested to be accumulation of substances with vitamin P activity.

Since the 1980 year the main focus of physiologo-biochemical investigations of wild plants in Kyzylkum is on the adaptive features of plants in natural phytocenoses in saline conditions (Alekseeva,Nigmatov et al.,1994). Parameters of functional activity (photosynthesis, respiration, water regime, carbohydrate, phosphorus, protein metabolism) of various phytocenoses with regard to species peculiarities of plants in specific growing coditions have been comprehensively studied. Correlations between habitat and corresponding zones of tolerance of physiological parameters including photosynthesis, respiration, transpiration, water holding ability, suction tension etc . are the basis of plant resistance to the conditions of salinization. The range of variability of some functions which allows plant growth in severe conditions of soil salinity is shown. Succulent halophytes are chracterized by high water content, low amount of pigments, low respiration level and low metabolism as a whole (Alekseeva,Nigmatov et al.,1994).

3.Conclusion

As a result of long-term investigations physiologo-biochemical characteristic of wild plants adaptation to arid growing conditions has been given. Specific character of the physiological and biochemical characteristic features in a large number of desert plant species (nealy 150) was revealed. Between species it was determined a large differentiation on functional adaptation to growing conditions. Conducted investigations give concrete material for characteristic of certain species, their resistance. Level of adaptation to environmental conditions, extend our knowledge of gaseous exchage ecology and wild plant metabolism in arid zone. Presented work is to a certain extent,a contribution to the solution of a problem of biodiversity of vegetable kingdom.

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Kochia: A Real Option as a Fodder Crop for Arid Zones

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Abstract - The objective of this study was to show the potential of Coquia (*Kochia scoparia* L. Schrad var. esmeralda) as a good option for forage production in arid and semiarid zones of Mexico. This plant is drought resistant and it grows well in eroded soils. It can be a good complement to the rations for different animal species (bovines, ovines, caprines, rabbits and equines).

Keywords: coquia, fodder crop, animal nutrition, agronomic aspects.

1.Introduction

This plant represents an option in order to reduce deaths of livestock from lack of forage; it grows well in arid and semiarid lands, it could also adapt to subhumid zones and produce forage in the dry time of the year (Erickson, 1947; Durham and Durham, 1979; Foster, 1980; Anaya 1993).

Coquia (*Kochia scoparia L. Schrad*) of the Chenopodiaceae family, originated in the saline depression of Barabinskaya, near Novosibirsk in the Central-South region of Asia and was introduced to America at the beginning of this century. In Mexico, it has been used for more than 25 years (Anaya, 1989).

Coquia is a low-cost annual plant, with high protein content, drought resistence and adaptation to a great variety of soils including saline and eroded soils (Anaya, 1992).

During drought periods, livestock loss caused by a shortage of forage can be a severe problem worldwide. To reduce these losses, new fodder plant options must be examined, particularly in Mexico, where the shortage of forage is becoming worse on many states. Kochia has a great adaptability; it is located in the five continents. The area dedicated to this species is unknown; however, its use is growing.

2.Agronomic Aspects

The seeding method is the same as for alfalfa; in uneven lands it could be sowed to the volle. It is recommended, not to cover the seed with more than 3mm of soil, with a seed density of 4 to 8 kg/ha. Soils should be naturally fertile. There is, preference for organic matter or fertilization with 60 kg/ha of nitrogen and 40 kg/ha of phosphate (Coxworth and Kernan, 1988; Coxworth *et al.* 1988).

The seeding date of Coquia is January through May under irrigation conditions. Under rainfed regime for arid and semiarid zones , it should be sown at the beginning of the rains and in humid and subhumid zones, with the last rains (Hoechst, 1992; Osuna, 1985; Anaya, 1993). Coquia may be sown with other forages such as oats, salty grass and barley, in a mixed stand.

The stand should be cut at 5% flower, the period when the plant reaches its highest protein content,

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which ranges from 16 to 28% (Finley and Sherrod, 1971; Farias, 1985; Hernández, 1986; Anaya, 1989; Reyna, 1994). It is important to cut the crop 15 cm. from the soil surface in order to facilitate branching.

3.Water Consumption and Yield

Coquia is also distinguished for its low consumption of water. It requires 3 or 4 times less that what alfalfa needs since rainfall of only 200 mm can produce 40 to 60 tons of green forage per hectare. When irrigated with 50-60 cm of water, the production could reach 80 to 130 tons per hectare of green matter (Table 1). Coquia can be effective in reducing aquifer over-exploitation.

Table 1. Coquia yields in different regions of Mexico. *

Regions	yield of green matter 1st. cutting, ton/ha	crude protein %
Arid and semiarid zones		
Tecamac, México	30-40	17-21
Metzquititlan, Nopala, Alfajayucan, Huichapan, Chapantongo y Tecozautla, Hidalgo	25-120	16-28
León, Guanajuato	40-60	17-21
Perote, Veracruz	20-30	16-18
Zaragoza, Coahuila	15-20	16-18
Chapingo, Méx.	20-30	16-19
(Hard pans)		
Temamatla, México	40-70	18-24
Montecillo, México	70-130	18-28
Saline soils		
Comarca Lagunera	40-70	18-22
Laguna de Sayula, Jalisco	50-70	17-21
Ex-lago de Texcoco. Méx.	35-65	16-20
Costa Hermosillo, Sonora	35-60	19-23
Cuitzeo, Michoacán	20-30	17-20
Mixquic, México	35-100	18-26
México, D.F. (abandoned urban areas)	40-90	19-22

* Different sources of information

4.Advantages

Some advantages of Coquia are the following:

- Wide adaptation to climates and soils,
- Tolerant to salinity,
- It grows in eroded soils,
- Resistant to drought, once established in good soil conditions,
- Germinates at low temperatures,
- Resistant to insects and diseases,
- Plant of high palatability, good digestibility and low in fiber,
- From quick growth, it could produce up to 300 kg/ha/day of dry matter,
- The forage could be conserved in form of silage, hay and pellets,
- Forage of high quality, comparable with alfalfa,
- Economic and high benefit/cost. ratio

This plant grows from zero to 3600 meters above sea level, pH from 5 up to 12; it tolerates low temperatures upon germinating.

5.Handling

Since Coquia is a vigorous plant, it requires minimal care. However, it may be necessary to use protective fencing to evaluate the benefit of the plant in enhancing recovery of rangeland. Weeds should be removed to reduce competition.

Coquia is a versatile forage, since the livestock could graze it directly, or it may be used for silage, hay and pellets. It requires minimum care and the cost of cultivation is low, since seeding rate is 4-8 kg per hectare. Also, one could sow in a blend with oats, and other fodder plants.

Its high protein content is an asset in the diet and average daily gain may be 200-300 grams in sheep and 800 to 1,200 grams in cattle.

When Coquia is provided as 35% of the total animal diet, the consumption of water increases 25% overall when the forage comes from saline soils.

This plant is recommended for up to 35% total of the diet of ruminants: livestock for meat, livestock for milk, goats and lambs; and up to 50% in equines, pigs, chicken and rabbits. It is also used as a salad for human consumption (Sherrod, 1971; Sherrod, 1973; Rodríguez, 1988; Santana, 1991; Anaya, 1996).

6.Socio-Economical and Ecological Potential

From the social and economic point of view, Coquia represents an option for the production of forage since it grows well in arid, semiarid and subhumid zones. This plant represents a high socioeconomical potential for the communities dedicated to cattle production, where rainfed systems of production prevail. In areas under irrigation it is a good alternative in order to reduce the depression of the aquifer levels. With 20 tons of green forage per hectare, a benefits:cost ratio of 1.5 is obtained, which lowers considerably the costs of production in the animal production activities. Also, one could use it as a source of protein in balanced foods. Given its high potential of production, it fixes CO_2 and improves the environment.

In Mexico, more and more institutions of teaching, research and technological development as well as official dependencies, state governments and non goverment organizations carry out research and demonstrations of this excellent plant, because of the support for its use and handling by several types of agricultural producers. At the moment, in Mexico, seed is available for diverse ecological conditions.

7.Conclusion

With all the qualities and advantages that Coquia offers, this forage is becoming not an alternative, but a real forage production option.

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Response of Wheat and Cotton to Fertiliser Application on Soils of Arid Region in Punjab (India)

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Abstract - Of the three soils examined for response of wheat and cotton to N and P application, the yield in the unfertilized plots increased with increasing fineness of the soil. The yield response to N was observed upto 120 kg N/ha on two coarser soils and upto 180 kg N/ha on the fine textured soils. Response of cotton to N application was observed upto 100 kg N/ha on the fine textured soil and upto 50 kg N/ha on the coarser soils. The response to P to wheat was observed upto 60 kg in coarse and fine loamy Ustochreptic Camborthids whereas in the Torripsamment the response was upto 30 kg P_2O_5/ha. The response of cotton to P application was not significant on all the three soils.

Key words : Arid soils, cotton, wheat, nitrogen, phosphorus

1. Introduction

Performance of any crop on a given soil is largely dependent on soil characteristics, climatic conditions and management practices. The Punjab state in North-West India comprises three distinct climatic zones viz humid, semiarid and arid which cover 10, 74 and 16 per cent area of the state respectively (Sharma et al., 1992). During the last three decades considerable success has been achieved by increasing agricultural production 3 to 4 fold by developing soil, water and fertilizer management strategies on semiarid soils having assured irrigation facilities. However, agricultural production in the arid zone has not shown comparable progress.

Soil family as a unit has been claimed to be very useful for agrotechnology transfer (Silva,1985). By conducting soil and crop management research on well defined soil families with possibilities of their transferability to similar soils, the cost and magnitude of agricultural research may effectively be reduced. Soil Taxonomy has been in vogue in India since the early seventies. However not much effort has been made to test the claim of the results of soil and crop management experiments. In order to achieve this, field experiments on fertilizer management in wheat and cotton were, therefore, carried out on three widely occurring and agriculturally important soil families represented by three soil series in the arid zone of Punjab.

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2.Material and Methods

To study the response of graded levels of fertilizer application to wheat and cotton, field experiments were conducted on Jassi Pauwali (mixed, hyperthermic family of Torripsamments), Jodhpur Ramana (coarse loamy, mixed hyperthermic family of Ustochreptic Camborthids) and Gahri Bhagi (fine loamy, mixed, hyperthermic family of Ustochreptic Camborthids) soil series (Sidhu and Sharma,1990).

For wheat, four treatments comprising four levels of N (0, 60, 120 and 180 kg/ha) and four levels of P_2O_5 (0, 30, 60 and 90 kg/ha) were given in a randomized block design. Wheat crop variety WL 2329 was sown in 5 x 5 m plots in 22.5 cm wide rows in last week of the November and harvested in the last week of the April. Grain yields were recorded. Six irrigations each of 7.5 cm were applied to all the treatments.

For cotton, four levels of N (0, 60, 100 and 150 kg N/ha) and four levels of P_2O_5 (0, 30, 60 and 90 kg/ha) were tried in a randomized block design. Cotton variety F-1054 was sown in the first week of May and total yield was recorded after the last picking in November. Three irrigations each of 7.5 cm were applied to all the treatments. During the cropping season all the plant protection measures were adopted according to Punjab Agricultural University recommendations.

3. Results and Discussion

3.1 Response of wheat to N application: The grain yield in control plots varied from 1290 to 2180 kg/ha (Table 1) with lowest and highest yields being obtained in Jassi Pauwali and Gahri Bhagi soil respectively. The lowest yield in Jassi Pauwali soils may be ascribed to the coarse texture of this soil (Sharma et al., 1990). Although the Jodhpur Ramana series is somewhat similar to Jassi Pauwali in terms of texture of surface soil, the higher yield in the Jodhpur Ramana series appears to be due to finer texture in the sub-surface horizons of this soil.

Table 1. Grain yield (kg/ha) of wheat as affected by N application in different soil series

N applied	GahriBhagi Fine Texture	Jodhpur Ramana Coarse Texture	Jassi Puwali Coarse Texture
0	2180	1570	1290
60	3690	3010	2220
120	4210	3270	2700
180	4600	3570	3480
LSD(0.05)	310	240	380

Yield increase with the lowest level of applied N (60 kg/ha) over control varied from 930 to 1510 kg/ha on the three soil series. The magnitude of increase in wheat yield with additional increments of 60 kg N narrowed down on the fine textured soil series. It can be inferred from these data that response to application of additional N was more in coarse loamy/sandy families as compared to fine loamy families.

3.2 Response of wheat to phosphorus application: The yield level in the unfertilized plots was highest (3410 kg/ha) in Gahri Bhagi soil series, lowest (2110 kg/ha) in Jassi Pauwali series and intermediate (2550 kg/ha) in Jodhpur Ramana series (Table 2).

Table 2. Grain yield (kg/ha) of wheat as affected by P application in different soil series

P applied	Gahri Bhagi Fine Texture	Jodhpur Ramana Coarse Texture	Jassi Pauwali Coarse Texture
0	3410	2550	2110
30	3660	2830	2510
60	3880	3010	2540
90	3730	3040	2530
LSD(0.05)	310	240	380

A singificant response to added P was observed upto 30 kg in the Jassi Pauwali and Jodhpur Ramana series whereas in the Gahri Bhagi series the yield did not increase significantly with application of P. The wheat yield increased from 250 to 400 kg/ha in the three series with first level of P application (30 kg/ha). The lower response to P application in Gahri Bhagi series may be attributed to its higher P fixing capacity because of finer texture (Longanathon and Sutton,1987) than the other two series. The bulk of the added P in this soil may have been fixed on the adsorption sites thus, resulting in low response to applied P. However, increase in P dose by an additional 30 kg/ha increased the yield non significantly in two soil series by 220 kg/ha (Gahri Bhagi) and 180 kg/ha (Jodhpur Ramana). The results suggest that an application of 30 kg P_2O_5/ha to wheat in the coarse soils series can be remunerative.

3.3 Response of cotton to N and P application: The cotton yields in the unfertilized plots increased with increasing fineness of the soil (Table 3) varying from 810 (Jassi Pauwali) to 1530 kg/ha

Table 3. Cotton yield (kg/ha) as affected by different levels of N in three soil series

N applied	Gahri Bhagi Fine Texture	Jodhpur Ramana Coarse Texture	Jassi Pauwali Coarse Texture
0	1530	1210	810
50	2350	1990	1220
100	2360	2040	1520
150	2370	2030	1530
LSD (0.05)	220	370	210

(Gahri Bhagi). Higher yield in the Gahri Bhagi soil is attributed to finer texture, higher nutrient availability and better water holding capacity of the soil. The response to added N was observed upto 100 kg N/ha in the Jassi Pauwali series whereas in the other two series the significant increase in cotton yield was obtained only at the lowest level of 50 kg N/ha. The increases in yield were 820, 780 and 410 kg/ha in Gahri Bhagi, Jodhpur Ramana and Jassi Pauwali series respectively. The response of cotton to N application upto 100 kg/ha in Jassi Pauwali as compared with 50 kg N/ha in Gahri Bhagi and Jodhpur Ramana series may be due to more leaching of N beyond the rooting zone during the monsoon season.

The response of cotton to P application was not significant in all the three series though the yield level in the unfertilized plots was higher in the Gahri Bhagi than Jassi Pauwali and Jodhpur Ramana soil series (Table.4).

Table 4. Cotton yield (kg/ha) as affected by P application (kg/ha) in three soil series

P applied	Gahri Bhagi Fine Texture	Jodhpur Ramana Coarse Texture	Jassi Pauwali Coarse Texture
0	2080	1750	1200
30	2160	1840	1300
60	2180	1850	1330
90	2180	1860	1320
LSD (0.05)	NS	NS	NS

Although the soils are low to medium in available P, due to the deep rooting system the crop requirements are met from the profile P. For this reason it is believed that P application had no beneficial effect on cotton yield.

4 Conclusions

The soils are deficient in N and P and response to applied N and P is more in coarse loamy and sandy families as compared to fine loamy families. The response of cotton to P application was not significant in all the three series. It can also be concluded that two of the soil series (Jassi Pauwali and Jodhpur Ramana) were quite similar and produced similar results, although they get placement in different taxa as per soil taxonomy. It shows that the paradigm suggested by Silva (1985) may not fully be translated in reality.

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New Technologies for the Rehabilitation of Arid Areas

Keynote Address

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New Technologies For Land Rehabilitation
A Keynote Address

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Abstract - The need for land rehabilitation has never been greater and will continue to expand as nations develop and utilize their natural resources. Rehabilitation of land disturbances assures sustainable productivity of our natural resources and preserves opportunities for future land uses. The most effective land rehabilitation plans are made prior to incurring land disturbance activities. Existing technologies are available for arid environments, however challenges still exist for innovative ways to capitalize on locally available resources and products.

1. Introduction

The arid and semi-arid regions of the world are some the last remaining environments to be explored for their natural resource values. Our deserts are now known for their significant forage values and economically valuable minerals such as gold, silver, and copper. As nations extract and utilize their resources, a very conscientious effort must be made to assure that any disturbances associated with pursuit of these resources be rehabilitated in a manner that will result in long term productivity of the land.

It is my privilege this evening to share with you my experience with arid land rehabilitation. I have had a lifelong interest in plants; particularly plants that can be used for conservation. Plants form the elemental basis of all food chains. Sustained productivity of natural ecosystems requires suitable soil resources supporting plant growth. The fundamental objective of rehabilitation, therefore, is control of soil erosion through vegetation reestablishment.

2. Disturbances in Desert Environments

Land disturbances come in all shapes and sizes. No two are ever exactly the same. Each situation therefore requires site-specific rehabilitation planning including analyses of soil conditions, climate, and the desired post-disturbance land use. However, for practical purposes, land disturbances commonly associated with arid and semi-arid regions might be categorized as follows.

2.1 Wildland Fire   Wildfire is becoming increasingly prevalent in the semi-arid regions of North America. Burned landscapes are denuded of vegetation, at least temporarily, leaving soil resources intact but severely vulnerable to erosion. (This type of disturbance is similar to other land clearing activities, such as forest clear cutting.) These conditions set the stage for invasion of less desirable plant species such as *Bromus tectorum*. Replacement of native perennial species by exotic annuals in desert environments degrades the ecological site

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potential by reducing biomass productivity and species diversity which limits future land use. These communities also become seriously at risk for increased frequency of wildfire occurrence.

2.2 Improper Grazing Management With a rapidly growing world population, food production demands are increasing exponentially. The need for food production with little or no input places high demands on world land resources in all environments ranging from arid to tropical. Livestock production is one means of satisfying much of the food protein need.. Livestock grazing has extended over vast areas of the earth. Forage resources in many places have become devastated due to mismanagement, lack of technology or technology transfer, and the effects of climatic events on overgrazed and denuded soil surfaces. The problem appears to be one of awareness, access to technical knowledge, and availability of experienced practitioners. Proper grazing management of large herbivores is essential to assure sustainable production of our rangeland and pasturing areas of the world. Applied management will assure that food production remains stable and economies thrive. Mismanaged rangelands, like other disturbed lands, are difficult and costly to rehabilitate once deteriorated to a poor condition.

2.3 Mining in Desert Regions Mining activities in our desert region have changed dramatically over the past few decades. Where mines were once small in size and extraction mostly accomplished from underground shafts and adits, the picture is quite different today. Cyanide extraction processes have allowed for recovery of microscopic particles of gold at a reasonable cost. The western state where I live, Nevada, was recently cited as the second largest producer of gold in the world. Open pit gold mines in my state and throughout the world disturb significant areas. Types of disturbances include:

- Open Pits - Complete eradication of soil and vegetation resources leaves little, if any, potential for rehabilitation due to economic constraints.
- Waste Rock Dumps - Displacement of vegetation communities and surface placement of subsurface soils and rock, sometimes unoxidized, acid-forming materials, requires topsoil application or soil amendment to provide a suitable plant growth medium for revegetation.
- Cyanide Leach Pads - Surface placement of crushed ore materials saturated with very dilute cyanide solutions result in heavy metal concentrations and saline-sodic conditions unsuitable for plant growth.
- Administrative Facilities and Roads - Removal of vegetation leaves soil resources intact which are generally conducive to revegetation.

3. Successful Techniques for Rehabilitation of Arid Lands

The desert environment is possibly the most difficult to address when attempting rehabilitation. Limited topsoil, and more importantly, the limited precipitation for germination and establishment presents a formidable challenge. The challenge at hand is one of limited technology to address deficiencies in plant growth mediums and availability of adapted plant materials. Fortunately, land rehabilitation procedures are now generally quite refined and, in fact, is an industry of its own. Standard procedures however, frequently need to be modified for site specific needs, particularly in desert environments.

3.1 Soil Suitability The availability of suitable plant growth medium is the first consideration in rehabilitation. When topsoil resources are completely lacking, the challenge becomes amending non-soil material to create a plant growth medium. Mine waste, for example, can be characterized by unoxidized, acid-generating minerals. Soil chemistry analyses can be used to calculate lime amendment prescriptions to raise pH levels into tolerable ranges for plant growth. Gypsum application is used for the reverse process of lowering excessively high pH levels resulting from excess sodium levels which are characteristic of many desert soil types.

Other physical properties such as soil color can have a significant effect on the success or failure of plantings. Soil temperature data from central Nevada exhibited differences of about 11 degrees C (20 degrees F) on heap leach pad material of varying color. Although many seeds germinated on the dark material, the seedlings perished over a short time period, being unable to tolerate the rising temperatures. Lighter colored material sustained seedlings significantly better due to cooler surface conditions. The solution to the color problem was found with a thin application of light colored soil/rock material. Applications of light colored straw mulch or other heat refractive material might also address temperature limitations and should be tested.

3.2 Soil Moisture Available moisture for plant establishment has always been a challenge in the desert regions. Manipulating the soil surface to better trap and infiltrate limited supplies of moisture is a means of increasing available soil water for revegetation establishment. Contour furrows are an example of this process and that can be constructed when the slope gradient is conducive to operating heavy equipment. There is a need however, to develop more specialized equipment for operating on slopes and harsh soil conditions found on many project sites. To date, most of the contour furrowing work is accomplished with rippers on large caterpillar tractors or other track equipment.

While progress is being made and moisture retention innovations are becoming more available, the process has been slow and costly. Our company advocates the use of temporary irrigation for initial plant establishment when ever possible. Successful seedling establishment is never assured even with drought-adapted species. Soils moisture is generally adequate for germination under natural conditions, but does not support seedlings long enough for establishment. Successful establishment of native plants in undisturbed environments only occurs at of frequency of about once every 10 years or so in much of Nevada, when spring precipitation is above normal. Temporary irrigation assures that soil moisture throughout the establishment period will be sufficient.

3.3 Surface Mulch When applying either slope revegetation, or addressing protective needs of seriously disturbed soils in our region, we have found straw, from small grain crops to be one of the preferred surface mulch treatments following seeding. Rice straw is a particularly desirable surface mulch product due to its strength. Straw generally comes from local farms and is found to be lower in cost than many of the commercial products. We specify variable application rates for straw from 2,200 to 3,400 kg per hectare (2,000 to 3,000 pounds per acre) depending upon site conditions. Straw is secured by various methods including crimping, tackifier application, and stapled netting. A surface application of straw provides an ideal microenvironment for seed germination including cooler surface temperatures, better moisture retention, and increased water infiltration to the root zone. When used on slopes, the mutidirectional placement of straw creates "mini-dams" that retain and infiltrate moisture, prevent runoff and hold soils in place. As seeded plants become established, the straw eventually biodegrades.

3.4 Land Rehabilitation Using Livestock Livestock have been used as a tool to invigorate seedings, enhance soil conditions, and bury broadcasted seed. Livestock can serve a useful purpose by providing valuable soil amendments from dung and urination, and assisting in the planting process in regions where commercial products and equipment are not readily available. Livestock can be fed on steep slopes for effective trampling of seed and hay residue into the surface. Local ranchers are typically receptive to this approach, particularly when someone else is paying the feed bill while using their livestock. However, extreme care must be exercised with this treatment to control the grazing or trampling period and avoid negative effects which can result from over-utilization.

3.5 Test Plots and Greenhouse Trials In our experience, we have found that constructing test plots provides the site-specific biological assay necessary to determine the best choices for plant material selection. Neither climatic adaptation nor indigenous seed source can assure seeding establishment on harsh sites. Slope aspect, slope gradient, and wind seem to especially affect seeding success. Test plots can vary in size, however, we typically use a small tract of land, (0.25 acres or 0.1 hectares) at the actual rehabilitation location. Test plots are not necessarily intended nor designed for quantification and statistical analyses. However, replication of treatment is desirable for interpreting observations.

Test plots should be planted with a seedmix that incorporates both species of known adaptability and additional species that have good ecologic potential but have never been tried. Seeded test plots should receive mulch treatments that are feasible for the actual proposed rehabilitation project. New product testing can occur on test plots if control areas are established for comparative evaluation. A lead time of two years is necessary to evaluate the results of the test plot plantings. The results are then used to fine-tune the actual prescribed treatment. The test plots can assist in determining those species that are best adapted to the various exposures, slopes and plant growth mediums.

If time frames or other constraints do not allow for on-site test plot evaluation, seed mixes can be tested in greenhouse trials to reduce the seedling establishment period under controlled climatic conditions. Bench trials must be set up with the actual plant growth medium characteristic of the rehabilitation area. Greenhouse trials allow testing of plant material selection, but cannot provide insights to micro-environmental nuances.

4. Challenges and New Approaches for Land Rehabilitation

It is interesting for me to look back at my 30 years of experience and marvel at the rate that rehabilitation technology is improving in today's world. However, there remains several land rehabilitation technologies applicable to the more moist environments that have only limited application in the drier regions. These areas present a challenge for reclamation specialists and the research community, as land disturbing activities generally precede the research and technology necessary to assure success, and occasionally the regulations to ensure compliance.

4.1 Local Product Development for Land Rehabilitation When large scale projects are planned, such as an open pit mine, it is valuable to study the geographic area and determine the types of raw materials being produced that might serve as a product source for land rehabilitation. Rice straw is a good example of a crop residue that has highly desirable characteristics and widespread application in rehabilitation. Agricultural manure is valuable as a source of fertilizer and organic matter if free of noxious weed seed. Secondary-treated wastewater, or effluent, is used for irrigation to assist in rehabilitation projects where non-human consumption of plant materials is guaranteed. Sludge residues from sewer treatment plants also shows potential as an organic amendment to increase soil aeration, increase water infiltration, and water holding capacity. Flyash from coal-fired power plants has been used as a substitute for lime to raise pH conditions in acidic soils. Certainly the opportunity to create new product enterprises using local materials has merit, and would likely be viewed as a plus by local economies.

4.2 Weeds Weeds have traditionally been a concern and also a challenge where land disturbance occurs. Noxious weeds, are those weeds which are declared a serious problem because of their ability to out-compete native vegetation and prolific seed production. Noxious weeds are a growing problem throughout the U.S. primarily because of the stringent controls now applied on herbicide use. Chemicals were previously used to control weeds, but are now heavily regulated. Recently the emphasis and research funding has been directed principally toward biological control. There is concern that this setback in the use of chemicals will encourage outbreaks of noxious weeds where they previously were either absent or controlled. The emphasis on biological control will present sizable challenges for industry and research in the coming years and should not be taken lightly. It is critical that revegetation needs are addressed immediately following construction, or concurrent with the land disturbing activity whenever possible to reduce the spread of noxious weed invasion on all continents.

4.3 Non-Disturbance Rehabilitation While the concepts or land rehabilitation are usually considered for "catastrophic" events, land rehabilitation also applies to more subtle conversions of land degradation. In our region of the Great Basin, or cold desert, we have an abundance of biomass in the form of *Pinus monophylla* and *Juniperus osteosperma* (P-J) woodland. This woodland type is presently viewed as having limited multiple-use value as the overstory canopy is largely undesirable as a forage, and precludes understory species diversity. The P-J type occupies vast acreage and is rapidly encroaching on more productive lands at lower elevations. When harvested on-site as a whole tree, and processed through a chipper, the resulting wood product has potential for numerous uses. The raw chips can be applied as a surface mulch for erosion control, used in production of wood products, pulp, production of terpine and other chemicals, or used to fuel power generating plants. The possibility of generating power, creating new industries, controlling the spread of a problem tree species, and improving the natural environment represents potential for both economic and ecologic diversification .

4.4 Phytoremediation Land rehabilitation may also focus on remediation or detoxification of surface soils and surface waters contaminated through mining waste or unauthorized releases of petroleum based products. Current research is focusing on identifying plant species capable of not only surviving in these environments, but which are also able to detoxify or degrade the existing pollutant. Offshoots of Phytoremediation include Hyperaccumulation and Bioremediation. Hyperaccumulation involves the use of plants to recover trace levels of target metals such as nickel, gold or silver to concentrations in the parts per million range in plant tissues. Bioremediation utilizes bacteria to extract trace levels of metals from rinse solutions, degrade cyanide, or degrade petroleum spills in soils. The successful use of Phytoremediation requires an integrated approach, utilizing information from soil type, pH, and organic matter content to achieve the desired result. Cultural practices such as those I have been describing, may be well suited to maximize the effectiveness of Phytoremediation. However, continued research towards identifying additional, possibly native plant species for use in Phytoremediation as well as research to better understand the Phytoremediation process is greatly needed.

4.5 Soil Column Meteoric Tests The process of constructing soil columns to replicate conditions of heap leach pads or waste rock dumps allows testing of leaching and amendment treatments under actual and irrigated moisture conditions. Answers derived in short term lab applications expedite reclamation planning and constrain the need for extensive and costly soil amending processes. Many opportunities will be afforded through cooperative linkage between field and laboratory.

4.6 Alternative Water Supplies One of the more recent alternatives to heavy water usage, and one of growing interest in our region, is the use of treated sewage effluent for application to appropriate and safe areas. We are utilizing this effluent on such areas as golf courses, and selected agricultural lands. This process has taken what has been a serious waste disposal problem and converted it into a viable and valuable resource while not overtaxing our limited fresh water supplies. Land developers now compete for the luxury of owning a block of this treated effluent. Similarly, some progressive hotels have recently gone to recycling gray water through use of their own treatment plants and making efficient use of it in irrigation systems and water exhibit areas.

4.7 Dewatering Desert Basins Mining has the ability to remove overburden from mineral rich deposits at great depths today, due to modern technology. This process does however, commonly results in the need to pump ground water which seeps into the pit area. Dewatering large volumes of water can result in lowering of the water table and affect groundwater supplies for extended periods of time over large areas. More research is needed to be able to accurately model groundwater so that short and long term impacts can be predicted. In addition, new technology on processes for groundwater recharge is also needed.

4.8 Desertification A great deal of attention is being directed to the problem of desertification throughout the world today. This is particularly true of Asia where we read of vast regions being impacted by human activities including mining, grazing, and logging. While this is indeed a concern, I question whether there is consistency in characterizing the problem of desertification on different continents. The American Webster's Dictionary defines desertification as " the process of becoming desert... as from land mismanagement or climate change". It goes on to define a desert as "arid, barren land." I have been reading of "deserts" which are apparently evolving through mans activities in semiarid, humid and even tropical areas. More effort is needed throughout the world to define desertification in a consistent manner. Uninformed but well intentioned sectors of the public become unnecessarily alarmed causing great chaos for all of us if they misunderstand the problem. The greatest danger in misidentifying the problem is failure to formulate appropriate solutions.

5 Environmental Consideration

We live in a time of new expectations when it comes to the environment. The 21st century will bring changes we need to anticipate now. The public will demand even greater sensitivity to clean water, clean air, wildlife, and soil. Land disturbing activities in the U.S. now require a battery of environmental reviews and careful planning to secure permits. In addition, mine closure activities are being closely scrutinized and bonded to assure compliance with permit conditions. The world now is much smaller with improved travel, electronic communications and information exchange systems. Therefore, it is likely that more countries will be encouraged to develop stronger environmental policy in the coming years.

Of great importance is the need to bring reality into the process of laws and regulations, regardless of where they occur. The time to be effective in establishing national policy is early in the process. If good science and technology are available for land rehabilitation practices while serving practical needs, then a desirable outcome of reasonable regulations and policies can be anticipated. Too many laws are developed in a emotional or reactionary manner based upon input from organizations or individuals who are well intentioned but are also misinformed. Science can and should play a vital role in bringing facts into the process.

6. Conclusion

We have long recognized the value and importance of working with our clients to limit the area of disturbance to the specific need. Large equipment operators regularly strip areas far beyond that which is required for a project. This activity can result in elevating project costs, added reclamation challenges, and impact the overall appearance of the area. Some clients have taken this concern to heart and now require equipment operators to minimize disturbance, thus saving money and enhancing the appearance upon completion. Barriers can effectively be constructed from fencing material to establish limits of disturbance during construction. Limiting disturbances whenever possible is the best possible choice for reducing the cost and need for rehabilitation.

The information shared at this conference will further enable each of us to take back to our respective countries a greater appreciation of the land, its challenges, and the state of science throughout the world regarding land rehabilitation. Stronger resolve toward recognition of rehabilitation needs prior to initiating land disturbance activity will most often provide the answers needed to assure stable, productive, and sustainable environments following construction activities. Costs will forever be a major factor in land disturbing activities. Never the less, strong commitment to rehabilitation must be made on a worldwide basis for sustainability of productive natural resources.

New Technologies for the Rehabilitation of Arid Areas

Session Papers

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Reclamation of Heap-Leach Mining Spoils in Arid Environments

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Abstract - Heap-leach mining is used to recover microscopic precious metals in the Great Basin of western North America. Large amounts of rock waste are removed from open pits to facilitate the removal of ore. The ore, which contains only small amounts of precious metals per unit of volume, is crushed and piled (heaped) on impervious surfaces where dilute solutions of cyanide are leached through the material dissolving the precious metals. The two mine facilities requiring reclamation are the extensive rock dumps (as extensive as 2000 ha and over 100 m high) and the heap-leach pads (individually 50 to 200 ha in extent and 50 m high).

Keywords: soil moisture, nitrogen, weed competition.

1. Introduction

Large scale, open pit mining for recovery of precious metals is a 3 billion dollar (US) per year business in the Great Basin of western North America. Strict environmental regulations require the reclamation of areas disturbed by the mining activity (Young et al. 1995). Mining companies are required to post large cash bonds before they start mining to assure disturbed areas are reclaimed. The objectives of the reclamation seedings are to prevent accelerated erosion, prevent invasion of noxious weeds, and to return the disturbed areas to productive habitat for wild and domestic animals. In semi-arid to arid environments such reclamation seedings and ultimately, release from bonds, without the aid of irrigation is difficult.

2. Types of Disturbance

2.1 Pits Open pits from which waste rock and ore are extracted may be extensive (10 km by 5 km and 300 m deep). Unless the pits are backfilled there is little that can be done in the way of reclamation except to manage the lakes that are created once mine de-watering ceases. Pit lakes that form in abandoned mines become charged with soluble minerals making management of riparian habitats a problem, but they are not a direct reclamation by seeding issue.

2.2 Heap Leach Pads. Very few of the heap leach pads have existed long enough to be available for reclamation. The cyanide extraction process enriches the leached material with nitrogen. Coupled with the relative fine texture of the heap material, the pads should be a desirable site for reclamation plantings subsequent to cyanide and heavy metal detoxification. Preliminary seeding trials indicate that there may be a sodium hazard within the rooting zone of the heap material. Sodium cyanide solution was

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the source of the cyanide, and powdered limestone was added to the piles to maintain a high pH. The use of drip emitters to apply the leach solution may also have contributed to the precipitation of sodium in the heap material.

At the present time there is not enough experience with revegetation of exhausted heap leach piles to fully appreciate what, if any, problems will occur in the reclamation process. What is known is that precious metal exhausted heaps are not soils. Physically they are subsurface material that has been chemically altered through the cyanide extraction process. These materials must be chemically and physically amended to progress toward a desirable growth medium for reclamation.

2.3 Waste Rock Dumps. By far the bulk of the current reclamation seedings are located on waste rock dumps. Many mines are attempting to establish reclamation seedings concurrently with mining operations. This is advantageous because waiting to seed the dumps until the deposit is exhausted and the mine closes allows secondary succession to proceed on the waste dumps. This often results in dominance of weedy species that must be controlled before desirable species can be established. Secondly, concurrent reclamation allows the mine environmental staff to test different reclamation techniques on a smaller scale before the entire mine is reclaimed.

3. Waste Rock Seedings

3.1 Seedbeds The first step in reclamation seeding is the re-shaping of the dumps. Angle of repose dumps are virtually impossible to vegetate because of the continued erosion down the slope. In the foothills of mountain ranges the waste rock dumps are often re-contoured to blend into the surrounding topography. On valley floors it is difficult to make a 300 m rock dump appear as any thing except an artificial mountain. The important point of re-contouring is to reduce slopes for stability and to allow safe operation of mechanical equipment on the contour.

3.2 Top Soil One of the basic principals of mining reclamation in humid areas is the conservation of native top soil and re-applying the conserved material to the surface of the dump after it is re-contoured. In arid environments development of top soil is limited, and surface soils of deserts may be adversely affected by accumulations of soluble salts. If the desert top soil is a desirable material for plant growth it should be conserved and re-applied after recontouring. A determination of quality should be made in the early stages of mine development.

In practice, it has been determined that material that is of texturally suitable to support plant growth is often found in the process of removing waste material. This material may be hydro-thermally derived from the mineralization of the site and a more important source is fossil soils buried in alluvial fill. In basin and range type topography, the sinking basins are continually filled with alluvium from the rising mountains. These fossil soils are not biologically active in terms of soil micro-organisms, but they are weed free.

Mines produce a wide variety of waste material. Miners are required by regulation to pile potentially acid producing material on the interior of the dumps and bury it with basic rocks. No effort is made to sort the placement of the material based on ease in reclamation seedling establishment.

3.3 Forming The Seedbed After the dump is recontoured, one of the most successful techniques has been to rip the slope on the contour. Ripping is accomplished by mounting pointed steel shanks on a tool bar of a track laying tractor. The ripping action creates furrows up to 3 m deep. Usually, there is a 1 to 1.5 m interval between furrows. Ripping breaks surface compaction and creates micro-environments for water and litter accumulation. Contour ripping will be a critical technique for heap-leach pad reclamation.

3.4 Contour Furrows Finer textured particles in the seedbed are selectively eroded by wind and water to the bottom of the furrow. Often the bottom of the furrow is the only place in the seedbed where fine textured soil particles are sufficiently abundant to allow for seed coverage. The down slope or berm portion of the furrow provides a site free from continual burial that is inherent in unstable slopes. Small seeded species adapted to establishment on the surface of seedbed have a chance to establish on the berms.

Recontouring rock dump slopes tends to smooth and compact potential seedbeds. Contour furrowing roughens the seedbed and brings larger rocks back to the surface. This roughing of the surface creates micro-safesites that can support germination.

Obviously, the contour furrows trap moisture. A significant portion of the dump slope is solid rock so there is runoff even in arid environments. Care must be taken to insure the furrows are on the contour. If water accumulates in a low place in the contour, the berm may fail creating serious erosion problems.

3.5 Seeding contour Furrows The contoured furrowed rock dump sites are seeded by mechanical broadcasting. One method involves mounting broadcast seeders on the front and rear of the tractor that rips the slope for contour furrowing. Larger seeds that require soil coverage are seeded in front of the tractor and small seeds that can germinate from micro-safesites or from the soil surface are seeded behind the ripper. Currently, there are no drills available for precise seed placement on these steep, rocky, and irregular seedbeds. The negative aspect of broadcast seeding is the general lack of positive seed coverage.

3.6 Litter Applications A logical method for obtaining improved seed coverage would involve the application of litter or mulch treatments to the seedbed after seeding. In practice applying artificial litter in the form of straw has not consistently given superior results to simple broadcast seeding. The poor results with straw mulches apparently is the result of physical and biological aspects of the seedbed. Physically, there are problems with retaining the straw in place on steep, wind prone slopes. If the straw is held in place it may shed water rather than retain moisture. Biologically, these are very improvised seedbeds. Microbial degradation of the straw is very slow, but the few micro-organisms that are present use all the available nitrogen in the process of trying to break down the straw. Therefore, application rate is critical.

3.7 Nitrogen Dynamics Chemical analysis of the finer textured material used for seedbeds on rock dumps almost always reports very low levels of nitrogen. Fertilizing the seedbeds with nitrogen usually results in disastrous competition from highly competitive annual weeds. The annual grass *Bromus tectorum* is especially a problem in the Great Basin. This weedy annual thrives on nitrogen enrichment and will out compete other seedlings for moisture and close the sites to the establishment of perennial species.

Experience has shown that legumes or non-leguminous plants that symbiotically fix nitrogen can thrive in these nitrogen depleted seedbeds (Young *et al*. 1996). Valuable native shrub species such as *Purshia tridentata* can be established and grow well on rock dumps. The suitable mix of species to be seeded is that mix which is designed based on growth and site specific climatic conditions.

4. Conclusion - Seeding Success

The contour furrow method of seeding rock dumps has resulted in the successful establishment of the shrubs *Artemisia tridentata* and *Atriplex canescens*, as well as the herbaceous species *Agropyron desertorum*, *Linum lewisii*, and *Eschscholzia california* among other species. The creation of these diverse plant communities on bare rock dumps in 15 to 30 cm precipitation zones where the precipitation primarily occurs during the winter, and is largely out of phase with temperature permitting plant growth, is quite remarkable.

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Control and Rehabilitation of Tailings Desertified Land in Jinchang, China

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Abstract Jinchang city is located in a Ni and Co producing region in China. Tailings are emitted during refining of ore, and tailings desertification results in severe environmental pollution. According to the formation conditions and the situation of the tailings desertified land. Some issues concerns the a tailings reservoir with gravel and vegetation are discussed in this paper.

Key words: Tailings, Desertification, Control, Artificial vegetation

1. Introduction

Jinchang city is located in the eastern Hexi Corridor of Gansu province, the biggest producing region of Ni and Co in China. The old tailings reservoir of Jinchuan company, located on the north of Jinchang City, is about 3.15Km^2 and 38.77 million ton tailings were stored there from 1964 to 1991. Wind blows, dry and loose tailings sand out of the reservoir and black desertified land forms in the surrounding area.

2. Formation Conditions of Tailings Desertification

Drought, wind and rich fine tailings sand are the main reasons for tailings desertification in Jinchang.

In Jinchang, the annual average air temperature is 9.1 ℃. The average air temperature in January and July are -6.2 ℃ and 23.7 ℃, respectively. Annual average precipitation is 140.5mm. There are 74 days with wind-speed more than 8m/s and, 17 days with wind-speed more than 24m/s every year, the instantaneous maximum wind-speed was 34.2 m/s(1993.3.3). Wind-speed on the top of the reservoir could be described as follows:

$$Kn=(1+0.06H)V \qquad (1)$$

where Kn is wind-speed on the top of the reservoir, H is the height of the reservoir and V is the wind-speed on the ground. Strong wind causes tailings desertification.

On the other hand, sand rich in fine tailings is the raw material. The tailings were of small-size(as shown in table 1)

Table 1. Grain size distribution of tailings

grain size (mm)	>0.15	0.15-0.10	0.10-0.074	0.074-0.053	0.053-0.043	0.043-0.030	0.030-0.020	0.020-0.010	<0.01
percentage(%)	4.01	4.64	13.49	13.18	9.23	16.87	17.92	12.65	8.01

Owing to strong evaporation and percolation, the water in the deposited sludge lost very fast and its content is only 0.96%, the surface of the reservoir is dry and loose. Wind deposited these tailings sand in crescent dunes and a dune chain on the northeast and the north of reservoir. In the condition of nonpile movement, the rate of transferring sand followed the equation:

$$Q=(V_1-V_0)^{1.38} \qquad (2)$$

where Q is the rate of transporting sand; V_1 is wind-speed at two meter height; V_0 is threshold wind-speed of tailings sand at two meters height(here V_0 is 7m/s; R=0.91).

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3. Situation of Tailings Desertification

The tailings sand from the reservoir extend SE as far as 8 Km and pollute 5183 ha land. The contaminated area and deposited quantity of tailings are show in table 2.

Table 2. Contaminated area and deposited quantity of tailings

type of land	area(ha)	deposited quantity(m^3)
edge of reserve bridge	3.75	98760
forest land	74.00	148000
urban district	624.00	124800
discarded farmland	52.78	52776
farmland	287.22	84171
gobi grassland	4141.25	82900
total	5183	591407

The maximum thickness of the tailings layer in the abandoned field is 58 cm and its average thickness is 26.54 cm. According to the thickness of the tailings layer, the abandoned field is divided by 3 types(shown as table 3).

Table 3. The polluted types of abandoned farm land

Type	Thickness of tailings polluted layer(cm)	Percentage of polluted area(%)
Severe polluted land	>30	>50
Moderate polluted land	10-30	20-50
Slight polluted land	<10	<20

4. Control by gravel cover engineering

On the reservoir and the polluted abandoned farm land, gravel 5 cm deep was placed on the surface. According to the relationship between wind-speed and gravel size(shown in table 4), the grain size of 80% of the gravel must be larger than 0.5 mm, the surface covering gravel should be above 10 mm.

The covering was begun on April 6, 1993, and ended on September 17,1994. The control processes were:(1)repaired ways from quarries to reservoir; (2)leveled the surface of reservoir; (3)covered the surface of reservoir with gravel; (4) leveled the gravel.

Table 4. Threshold wind-speed of gravel

diameter of gravel(mm)	1-1.25	1.25-2.5	2.5-5.0	5-10	10-20	20-40	40-80
wind-speed at 6m height(m/s)	15.2	20.1	26.5	35.0	46.2	61.0	80.5
wind-speed at 10m height(m/s)	16.0	21.1	27.8	36.7	50.5	64.0	84.5

After controlling, the reservoir turned "black desert" into an artificial gobi. Tailings sand pollution and its harmful effects were eliminated. Sand transport rate on the reservoir is now only about 1/5133 of that before covering. 13 kinds of natural plants, such as *Suaeda glanca, Halogeton arachnoideus, Bassia dasyphylla, Nitraria sphaerocarpa and Tribulus terrestris* etc., invaded and inhabited, covered areas. The plant coverage reached up to 15-30%.

5. Constructing Artificial Vegetation

5.1 Vegetation Rehablitation on the Reservoir

Twenty species of tree and shrub were introduced on the reservoir. Survival and growth are shown in table 5. Most of the these trees can grow well on the tailings sands.

Table 5. Survival and growth of introduced trees and shrubs

tree species	investigation number	survival percent(%)	shoot yield(cm)	average root stock(mm)	depth of root(cm)	range of level root (cm)	adapta -bility
Elaeagnus angustifolia	134	86.44	47.7	11.6	42	4~38	++
Picea crassifolia	21	100	5.7	28.5	54	12~40	+
Rhus typhina	44	78.49	22.1	35.1	70	5~50	+
Sophora japonica	112	89.52	42.4	51.4	62	8~50	++
Populus gansuensis	123	93.92	44.0	22.0	64	5~60	+
Polulus abla	139	96.62	34.2	21.9	50	8~20	+
Robinia pseudoacacia	95	85.71	53.7	33.4	60	5~30	++
Salix babylonica	39	81.63	79.5	35.4	58	4~20	+
Fraxinus americana	69	71.17	8.7	32.7	41	3~32	-
Ulmus pumila	44	73.42	47.9	55.1	48	4~22	+
Tamarix sp.	350	95.12	58.7	4.3	28	5~38	++
Amorpha fruticosa	87	91.77	36.7	11.7	48	5~25	++
Caragana korshinskii	69	84.40	2.3	4.6	31	10~30	+
Haloxylon ammodendron	68	61.90	5.2	1.3	46	8~15	+
Artemisia ordosica	58	52.38	30.6	2.7	30	5~20	+
Sabina vulgaris	54	63.16	5.8	5.1	20	8~20	-
Caryopteris mongolica	45	89.06	15.4	5.0	26	17~23	+
Calligonum sp.	22	87.50	18.1	5.0	38	5~20	++
Polygonum sp.	22	58.70	6.1	3.5	~	~	-
Hedysarum scoparium	17	37.17	22.0	6.4	42	20~28	+

Note: ++ excellent; + good; - poor.

5.2 Crop Cultivation on the Abandoned Farmland

The content of Ni, Co and Cu in the test land and irrigation water are shown in table 6 and 7. Except for water melon and hami melon which had reduced yield, all species increased yield to some extent(table 8). The content of Ni, Co and Cu in the body of test crops can be shown table 8.

Table 6. The content of Ni, Co and Cu in the test land(%)

site	depth of sample	Ni	Co	Cu
test field	0~30	0.206	0.165	0.0114
contrast field	0~30	0.00477	0.00967	0.00139

Table 7. Metal ion content in the irrigation water(mg/l)

ion	Ni	Cu	Co	Zn	V	Pb	Cr	Mn
content	0.00061	0.00221	0.0005	0.00738	0.00026	0.00007	0.00069	0.00244

Table 8. Output and content of metal elements in agricultural products

sample	output(t/ha)		contents of metal elements(mg/kg)							
	test field	contrast field	sample position	type of sample	test field			contrast field		
					Ni	Co	Cu	Ni	Co	Cu
wheat	3.08	2.14	seeds	dried	10.7	0.18	14.6	3.3	0.14	10.6
barley	2.21	2.00	seeds	dried	5.6	0.15	9.0	2.6	0.15	8.1
broom corn millet	1.53	1.34	seeds	dried	26.3	0.60	14.1	15.8	0.27	6.4
soybean	2.78	2.14	seeds	dried	55.8	0.96	51.5	33.5	0.72	55.3
broad bean	2.16	2.44	seeds	dried	28.2	0.34	74.8	10.0	0.15	60.6
sword bean	24.96	9.67	fruits	fresh	6.9	0.09	5.6	2.00	0.03	4.9
potato	33.36	26.68	tuber	fresh	0.5	0.12	41.7	0.3	0.05	2.0
tomato	65.16	62.81	fruits	fresh	0.9	0.06	5.2	0.5	0.08	5.8
eggplant	29.14	28.92	fruits	fresh	4.5	0.31	64.2	3.0	0.12	15.2
red pepper	26.08	6.752	fruits	fresh	6.4	0.10	4.4	1.4	0.28	27.8
cauliflower	37.74	31.40	flower	fresh	2.6	0.05	2.3	1.2	0.01	8.1
winter white radish	40.27	41.68	root	fresh	1.0	0.05	18.7	0.7	0.09	2.0
water melon	44.22	67.14	fruits	fresh	1.4	0.07	0.8	0.9	0.06	1.2
bailan melon	30.87	44.57	fruits	fresh	1.1	0.06	0.2	1.1	0.07	1.4
hami melon	20.51	24.86	fruits	fresh	0.8	0.05	0.1	0.4	0.05	1.0

6. Conclusion

Drought, wind and sand rich in fine tailings lead to tailings desertification in Jinchang. In the climatic conditions, measures which can be described as "overlaying gravel, impoundment water, re-vegetation" is effectively control the tailings sand. The grain size of 80% gravel that is used must be above 0.5mm. *Elaeagnus angustifolia, Sophora japonica, Robinia pseudoacacia, Tamarix sp. Calligonum sp. and Amorpha fruticosa* are the better revegetation species on the tailings sands. The tailings sand increases the yield of the majority of test crops, but the content of Ni, Co and Cu is higher in these crop.

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Proactive Rehabilitation of Exploration Disturbances in Semi Arid Western Australia: Black Swan Nickel, Kalgoorlie

Darren BREARLEY* and Joan OSBORNE*

Abstract - The paper addresses remediation of areas disturbed by exploration activities; drill line disturbance and drill sump holes. The drill lines displayed some degree of vehicle compaction and related disturbance. Application of seed over scarified drill lines doubled the number of plant taxa present. Control and scarified drill line treatments (neither seeded) were characterised by dominant establishment of grasses. A greater range of life forms are present in the seeded treatment. The three sump hole treatments where deep ripping occurred are now dominated by chenopods. There has been successful plant establishment over disturbed highly saline sumps which contained hydrocarbon derivatives.

Key Words: Revegetation, Saline materials, Arid, Semi Arid, Chenopods

1. Introduction

1.1 Background Mining Project Investors Pty Ltd (MPI) and Outokumpu Metals and Resources Oy (OMR) hold Mining and Exploration leases (Black Swan Project) 50 km north-east of Kalgoorlie (Western Australia) on rangeland used for grazing sheep. An underground nickel mine has been developed.

Open eucalypt woodland covers most of the project area with acacias, cassias and eremophilas the dominant and characteristic woody perennial species on soils acidic in reaction. A succulent chenopod understorey is present where soils are more alkaline. Winter ephemerals from the Amaranthaceae and the Asteraceae are represented. The woodlands are in good condition. Many of the plant species tend to have widespread distributions, particularly the mulga zone acacias.

The main rehabilitation objective is to restore the disturbed areas to biologically sustainable ecosystems, requiring minimum long-term management. These are to be compatible with the pastoral land-use of the general area. Revegetation species will represent a range local to the area and matching the rehabilitation substrate.

The region experiences hot, dry summers and cool winters. In the temperate zones of Australia, Beard (1990) gives an arid classification to areas with an average annual rainfall less than 250 mm. Kalgoorlie (town site) records an average annual rainfall of 257 mm, with rainfall about equally distributed between summer-autumn (122 mm) and winter-spring (135 mm) (Pringle *et al.*, 1994). Winter rains are associated with southern depressions, and are more reliable (40 raindays).

1.2 Exploration The paper addresses remediation of areas disturbed by exploration activities. Exploration rehabilitation trials specifically address two different types of exploration disturbance; drill line disturbance and sump holes (RAB and RC drilling).

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There had been clearing of some passages of vegetation for the development of the geophysical and geological exploration grids. Although use has been made of existing access tracks and clearing of upper storey species (*i.e.* trees and large shrubs) has been minimised, understorey vegetation has been damaged by drill rig activity. There has also been ground compaction from light and heavy vehicular traffic.

A second disturbance has occurred in the latter stage of exploration, during evaluation of the ore body. Intensive drilling associated with final resource evaluation ultimately leads to ground disturbance over a selected area. Drilling water collected in adjacent sump holes is extremely saline, and contains drilling fluids and hydrocarbon by-products. Sampling indicated contaminated soil within the sump holes is extremely saline (Table 1).

Table 1. Salinity and pH: Sump hole materials (n = 2) for each sample description, noting maximum tolerance of pasture crops is 4 dS m^{-1} (ECe).

Site	Description	EC dS m^{-1}	ECe dS m^{-1}	approximate (ppm)	pH
1	control: not contaminated	0.82	6.57	4,205	6.22
2	saline and hydrocarbons	7.88	63.04	40,346	7.60
3	hydrocarbon materials	11.58	92.68	59,315	7.88
4	saline materials from drilling	32.97	263.73	168,787	7.60

The rehabilitation trials considered cost effective approaches for compacted and (or) contaminated exploration sites. Initial data are being used to ascertain how the surrounding disturbed area should best be treated in future years. For example there are over 100 sump holes within a 10 ha exploration area. Successful techniques can be applied to other exploration projects located in an arid climatic regime, where there are either benign or like contaminating materials.

2. Methods

2.1 Drill Line Trial The drill lines displayed some degree of vehicle compaction and related disturbance. The Drill Line Trial sought to determine whether scarification (surface ripping) and seeding of these disturbed areas increased revegetation success. Three treatments were incorporated into the following experimental design:

Treatment 1	control (no scarification, no direct seeding)
Treatment 2	+ scarification – seeding
Treatment 3	+ scarification + seeding

There were ten replicates of each experimental treatment; replicates measuring 20 m by 4 m. Ripping using a multi-tine grader was to 0.3 m depth. Manual seeding was at 6 kg ha^{-1} in early May 1996 (Table 2). No fertiliser was applied.

2.2 Sump Hole Trial The Sump Hole Trial sought to determine whether surface deep ripping, broadcasting of seed, and applying fertiliser increases revegetation establishment over highly saline disturbed areas containing hydrocarbon derivatives. Soil amelioration over time is also being considered.

The trial was established over sump holes for which associated mineral exploration drilling practices had ceased. Four treatments (10 replicates) were incorporated into the following experimental design:

Treatment 1	control (untreated)
Treatment 2	deep ripping – seeding+ fertiliser
Treatment 3	deep ripping + seeding – fertiliser
Treatment 4	deep ripping + seeding + fertiliser

Sump holes were filled by topsoil replacement and levelled using a front end loader. The surface was ripped by a multi-tine grader to 0.3 m depth. Two replicates each 10 m by 5 m cover a single sump hole. The seeding mixture was predominately local chenopod species, but also included some of the more salt tolerant acacias and eucalypts (Table 2). Seed was applied by hand (early May 1996) at a rate of 15 kg ha^{-1} over Treatments 3 and 4. A fertiliser with a high elemental composition of nitrogen and phosphorus ("Agras No. 1": 17.5% nitrogen, 7.6% phosphorus and 17.0% sulphur) was applied at 100 kg ha^{-1} to Treatment 4 replicates.

There was a first quantitative assessment of both trials in early December 1996 (revegetation age seven months). Plant growth parameters considered revegetation success, and provided comparison between experimental treatments (ANOVA and Fisher's test, $\alpha = 0.05$). There was detailed analysis of soil condition, allowing for documentation of changes over time.

Table 2. Seeding mixture with application rates (kg ha^{-1}) for Drill Line and Sump Hole (– not applied) Trials.

FAMILY Species	Drill Line kg ha^{-1}	Sump Hole kg ha^{-1}	FAMILY Species	Drill Line kg ha^{-1}	Sump Hole kg ha^{-1}
AMARANTHACEAE			**MIMOSACEAE**		
Ptilotus obovatus	0.18	–	*Acacia acuminata*	0.39	1.20
CAESALPINIACEAE			*Acacia aneura*	0.33	–
Cassia artemisioides	0.18	–	*Acacia hemiteles*	0.21	0.55
Cassia nemophila	0.36	–	*Acacia colletioides*	0.39	–
CHENOPODIACEAE			**MYOPORACEAE**		
Atriplex bunburyana	0.12	0.35	*Eremophila glabra*	0.15	–
Atriplex codonocarpa	0.21	1.15	*Eremophila maculata*	0.33	–
Atriplex nummularia	0.27	1.10	**MYRTACEAE**		
Atriplex semibaccata	0.15	0.75	*Eucalyptus lesouefii*	0.21	–
Atriplex vesicaria	0.27	1.30	*Eucalyptus salicola*	0.03	0.25
Enchylaena tomentosa	0.21	1.25	*Eucalyptus salmonophloia*	0.06	–
Maireana brevifolia	0.15	0.75	*Eucalyptus salubris*	0.06	0.55
Maireana georgei	0.36	1.25	*Eucalyptus straticalyx*	0.06	–
Maireana pentatropis	0.21	1.10	**PITTOSPORACEAE**		
Maireana sedifolia	0.21	1.10	*Pittosporum phylliraeoides*	0.18	–
Maireana tomentosa	0.21	1.10	**SAPINDACEAE**		
Maireana triptera	0.27	1.25	*Dodonaea lobulata*	0.12	–
			Dodonaea viscosa	0.12	–
			Total	**6.00**	**15.00**

3. Results and Discussion

Drill Line Trial data are presented in Table 3. Although application of seed over scarified drill lines had not significantly increased revegetation density or cover after the first growing season, almost twice the number of plant taxa was recorded within the seeded treatment. Treatment differences within the revegetation are expected to become more evident in following years, as plants become better established.

Table 3. Drill Line Trial: Mean densities (individuals m^{-2}) and cover (%) using 20 by 1 m transects, salinity (dS m^{-1}) and pH. Revegetation age seven months (ANOVA and Fishers Test with like means given by similar letters).

Treatment	Density m^{-2}	Species Richness	Cover %	n transects	ECe (dS m^{-1})	pH	n
control (no treatment)	1.740 ^{a}	16	0.602 ^{a}	10	0.49 ^{a}	6.34 ^{a}	30
+ scarification – seeding	0.900 ^{a}	17	0.435 ^{a}	8	0.83 ^{a}	6.39 ^{a}	24
+ scarification + seeding	2.013 ^{a}	28	0.974 ^{a}	8	1.04 ^{a}	6.35 ^{a}	24

The control and scarified treatments (neither seeded) were characterised by the dominant establishment of grasses, which comprised 80 percent[1] (14,000 plants ha^{-1}) and 67 percent (6,000 plants ha^{-1}) of the total revegetation density in each treatment respectively. Historical exploration in the area confirms grasses continue to dominate disturbed areas up to twenty years after clearing activities have ceased.

A greater range of life forms are present in the seeded treatment. Annual grasses have volunteered, however in lower numbers (18 percent of total density; 3,700 plants ha^{-1}). Eleven chenopod species provide 59 percent of the total revegetation density (11,900 plants ha^{-1}), with *Maireana georgei* the dominant species (2,400 plants ha^{-1}). The five *Acacia* spp. (800 plants ha^{-1}) and four *Eucalyptus* spp. (2,600 plants ha^{-1}) recorded will provide a middle and upper storey in the revegetation over the longer term.

Sump Hole Trial data are presented in Table 4. Significantly higher revegetation density and cover were recorded in the two seeded treatments. Higher average values were recorded for the fertilised treatment however differences between the two were not significant. Chenopod species are dominant. In the absence of fertiliser *Atriplex codonocarpa* and *A. semibaccata* provided greater individual ground covers of 2.7 and 1.8 percent[2] respectively. Fertiliser addition appears to have increased the productivity of a number of species, with *Atriplex bunburyana, A. codonocarpa, A. semibaccata,* and *Maireana brevifolia* recording individual cover values ranging between 1 percent and 4 percent.

[1] Additional data are available on request from an author.

[2] Additional data are available on request from an author.

Table 4. Sump Hole Trial: Mean densities (individuals m^{-2}) and cover (%) using 20 by 1 m transects, salinity (dS m^{-1}) and pH. Revegetation age seven months (ANOVA and Fishers Test with like means given by similar letters).

Treatment	Density m^{-2} n = 10 transects	Cover % n = 10 transects	Species Richness	ECe (dS m^{-1}) n = 30	pH n = 30
control (no treatment)	0.810 ^{b}	1.015 ^{b}	23	41.52 ^{a}	6.36 ^{b}
deep ripping – seeding + fertiliser	1.456 ^{b}	3.603 ^{b}	29	52.37 ^{a}	7.17 ^{a}
deep ripping + seeding – fertiliser	5.870 ^{a}	8.518 ^{a}	29	52.24 ^{a}	7.43 ^{a}
deep ripping+ seeding + fertiliser	7.195 ^{a}	13.250 ^{a}	33	29.97 ^{a}	7.53 ^{a}

Chenopod species dominate the three treatments where deep ripping occurred, giving 66, 81, and 88 percent of total revegetation density. In the control treatment fewer chenopods were recorded, contributing only 10 percent of the total density. Volunteering annual grasses dominate the control treatment, comprising 70 percent of the total density.

In the deep ripped, fertilised, not seeded, treatment 29 plant taxa were represented. The ten chenopod species gave 66 percent of total revegetation density, with *Atriplex semibaccata* covering over 1 percent of the total area sampled. Although this treatment was not seeded, deep ripping has increased the potential for seed lodgement from wind blown seed. Many of the species present have volunteered from neighbouring sown revegetation plots. Further assessment at the end of 1997 will elucidate trends in ecosystem development over a longer period.

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Improvement of Sodic Soil by Flue Gas Desulfurization Gypsum

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Abstract - The object of this research is to investigate an effect of desulfurization gypsum on the growth of wheat on the sodic soil. The possibility of desulfurization gypsum for the improvement of the sodic soil is proposed and examined to give an incentive for the construction of desulfurization units. The experiment of the growth of the wheat was carried out both on the pot and at the field in the northern part of China. It showed 0.15 wt% of desulfurization gypsum provides a greater harvest than the control. The effect of the waste from semi-dry desulfurization process was also examined.

Key Words: Soil Improvement, Sodic Soil, Desulfurization, Gypsum

1. Introduction

Improvement of sodic soil has been carried out by calcium sulfate, because of its general availability and low cost. Calcium sulfate is used as a source of (JD Oster, 1982):

1. calcium to replace sodium ion in the sodic soil;
2. electrolyte to control the swelling and dispersion of clays, so that water infiltration is improved.

In this work a flue gas desulfurization (FGD) gypsum is noted for the improvement of a large area of the sodic soil in the northern part of China. If this work elucidates the improvement effect of the FGD gypsum on the sodic soil, installations of the desulfurization processes will be promoted in China where most of coal combustion power plants have no desulfurization process at the present time.

In the developing countries, on the other hand, a semi-dry or simplified desulfurization process tends to be adopted owing to its low construction and running cost. However, the wastes from these processes contain calcium hydroxide, calcium carbonate, calcium sulfite and fly ash besides calcium sulfate.

The growth of wheat was examined on the pot and at the field in China to investigate the effect of the gypsum from not only the wet desulfurization process (F.IINO,1997) but also the semi-dry one on the sodic soil.

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2. Experimental

2.1 Wheat Growth The pot level experiments of the wheat growth with the FGD gypsum from both the wet and semi-dry processes were performed in 1995 (F.IINO, 1997) and 1996, respectively, in Japan. The sodic soil used in this experiment was imported from Shenyang city in China, and the chemical properties of the soil are shown in Table 1. The FGD gypsum from the wet process is almost pure, and the composition of the gypsum from the semi-dry is indicated in Table 2. In order to alleviate the alkalinity of calcium hydroxide, carbonation of the semi-dry FGD gypsum was carried out. The mix ratio of calcium sulfate (research grade) into the soil varied from 0.15 wt% to 5.0 wt% besides the control. The water content in the pot was controlled by keeping the weight of the pot constant by addition of water.

Table 1 Chemical Properties of the Soil

pH	9.8
EC	0.84mS/cm
CEC	6.5cmol(+)/kg(dry-soil)
Ca	10.7cmol/kg(dry-soil)
Mg	1.7cmol/kg(dry-soil)
K	1.1cmol/kg(dry-soil)
Na	7.6cmol/kg(dry-soil)

Table 2 Chemical Properties of the Semi-dry FGD Gypsum

	Non carbonated(wt%)	Carbonated(wt%)
$Ca(OH)_2$	20	0
$CaCO_3$	20	40
$CaSO_3$	35	35
$CaSO_4$	20	20
pH	12,6	8,4

The field experiment was carried out in 1996 in the northern part of Shenyang, China. Considering that the corn is the staple crop around these areas, the growth of the corn on the sodic soil was examined in the field of $200m^2$. The precipitation between April and September is 489.7mm annually.

2.2 Analysis The top (2cm) and the bottom (2cm) soil of the pot was prepared for analysis by drying it at 80℃ for a night and being crumbled and sieved under a 2mm size. Electric conductivity of a 50ml solution mixed with 10g soil and pH of a 25ml solution mixed with 10g soil were measured at about 25℃. The concentration of sodium and calcium ion in the soil were determined by atomic absorption analysis. The solutions for the analysis were prepared by a 50ml of 1 mol/l acetic ammonium solution stirred for an hour and filtered. A solution of Sr (1000ppm) was added to prevent the ionization of calcium in the flame.

3.Results and Discussion

3.1 Pot Experiment The dry weights of the wheat on the soil mixed with calcium sulfate (research grade), the semi-dry FGD gypsum, and the carbonated one are shown in Figs.1,2,and 3, respectively. In Fig.1, it is clear that a mix ratio of 0.15 wt% calcium sulfate provided a greater harvest than the control (0 wt%). Although the semi-dry FGD gypsum dramatically improved the sodic soil in the case of 0.5 wt%, mixing more than 0.5 wt% harmfully affected the wheat growth (Fig.2). Carbonation of the semi-dry FGD gypsum alleviated the alkalinity of the calcium hydroxide, but it didn't improve the soil as well as pure calcium sulfate (Fig.3). It is concluded that the salinity except calcium sulfate in the carbonated semi-dry FGD gypsum weakened the improvement effect of calcium sulfate.

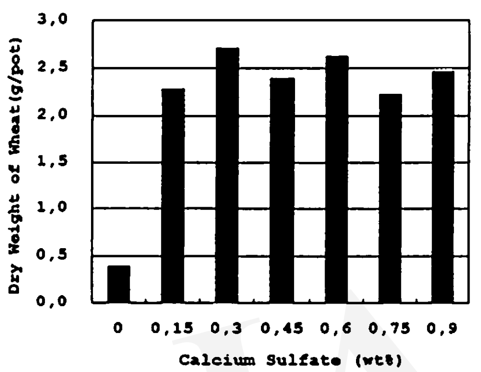

Fig.1 Effect of Calcium Sulfate on the Sodic Soil

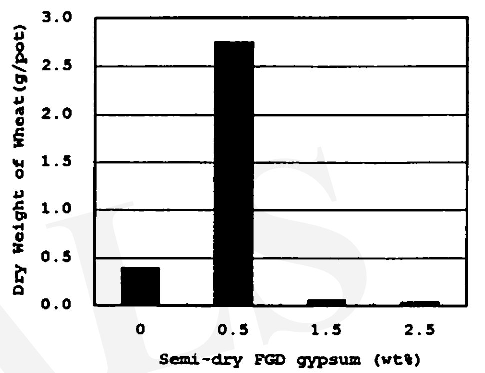

Fig.2 Effect of Semi-dry FGD gypsum on the Sodic Soil

3.2 Soil Analysis The changes of pH in the case of calcium sulfate and the semi-dry FGD gypsum are indicated, respectively, in Figs.4,5. While the value of pH decreases with calcium sulfate (Fig.4), the value is constant around 10 in the case of semi-dry FGD gypsum (Fig.5). A little difference can be seen between the pH values of the top and the bottom soil, when the gypsum was mixed. The concentrations of calcium and sodium in the pot are illustrated in Fig.6. At 0.5 wt% of the semi-dry FGD gypsum it is observed that sodium ion transferred to the bottom of the pot. This transfer may result in a good harvest of the wheat.

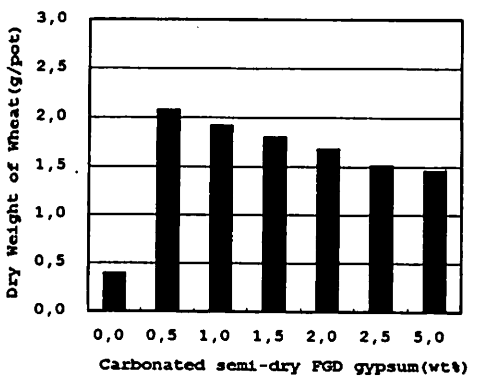

Fig.3 Effect of Carbonated semi-dry FGD gypsum on the Sodic Soil

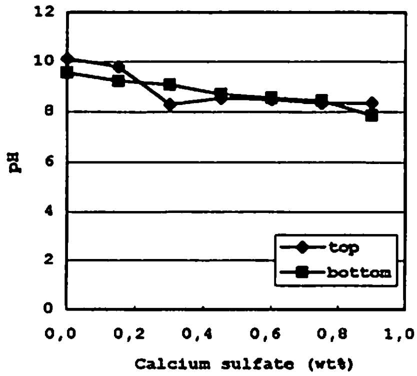

Fig.4 pH change by mixing semi-dry FGD gypsum as obtained (wt%)

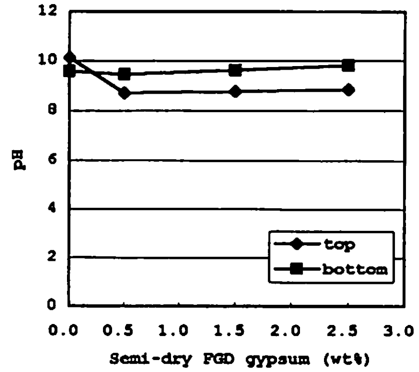

Fig.5 pH change by mixing semi-dry FGD gypsum (wt%)

3.3 Field Experiment The wet FGD gypsum imported from Japan was mixed with the sodic soil in Shenyang. The corn normally grew in the plot of 1.0 wt%, whereas the worse growth was observed on the control plot.

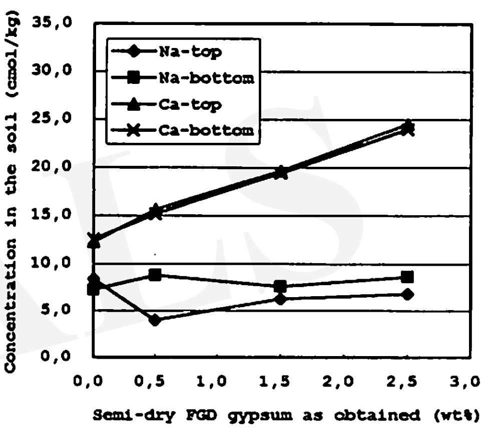

Fig. 6 Calcium and sodium concentrations in the pot soil

4.Conclusion

Addition of 0.15 wt% of calcium sulfate into the sodic soil dramatically improved the wheat growth on the pot experiment. The semi-dry FGD gypsum also have the possibility to be effective of improving the sodic soil at the mix ratio of 0.5 wt%. However, the effect accompanied the risk of damaging vegetation by the strong alkalinity. On the other hand, carbonation of the semi-dry FGD gypsum alleviated the strong alkalinity and provided the better growth, although it is not so good as in the case of calcium sulfate.

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EXPANSION OF REVEGETATION TECHNOLOGY ON SALT-AFFECTED LANDS FOR SUSTAINED PRODUCTION IN AN ARID REGION

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Abstract - Salt-affected soil is more common in countries which have regions encompassing semi arid, arid and seasonally dry tropical climates. Climatically, Pakistan has 36 ecological zones with a total area of 80.5 mha. Out of this, 20.5 mha are cultivated; of this 16.2 mha are irrigated: about 11.4 mha are irrigated by canal and the rest by pumped ground water. About 6.3 mha are degraded because of salinity problems. Most of the salt-affected area lies in the arid, hot, sub-tropical continental regions receiving monsoon rains. This area covers the deserts of Thal, Cholistan and northern Tharparkar; the Piedmont plains of D.G. Khan, D.I.Khan, Sibi and Kachhi districts, and sub-recent and recent river plains of the Indus, Jhelum, Chenab, Ravi and Sutlej rivers. The region is the driest part of the lowland area with rainfall of less than 250 mm, about 80 per cent of which falls in summer. Reclamation of these salt affected lands is expensive. Revegetation of the salt-affected lands with suitable species has thus a special economic significance in the country, particularly in areas which are beyond the canal command, and poor quality ground water is the only source of irrigation.

1. Introduction

Water deficit and soil salinity are the two most important and interlinked problems of Pakistan's irrigated agriculture. In spite of over 100 MAF (million acre feet) of water being diverted annually into canals, net water available at the water course head is only 70.35 MAF against the requirements of 134 MAF. This deficit is met partially through tubewells to the tune of 32 MAF (Ahmed and Chaudhry, 1988). Over 70% of tubewells pump water of poor quality (Ahmed and Chaudhry, 1990). The quality of ground water thus limits its use for irrigation and soil reclamation purposes. Economic use of salt-affected waste lands for agricultural purposes, therefore, has special relevance to Pakistan which has about 6.3 million ha of salt-affected land (Khan, 1993). Out of which 3.16 mha are within canal commands and 2.93 mha are cultivated/cultivable (Rafiq, 1990). At present, Pakistan experiences huge recurring losses because of reduction in yield due to salinity and, according to an estimate, in moderately salt-affected cultivated regions, there are reductions of 64, 68, 59 and 62% in the yields of wheat, rice, cotton and sugarcane, respectively as compared to normal non-saline soils. The total loss thus comes to between 0.3 and 1.0 billion $US per annum (Qureshi, 1993). Reclamation of these lands through chemical and engineering treatments is very expensive. Since following a "drainage-irrigation" strategy to control waterlogging and salinity the Govt. of Pakistan has spent over 3.0 billion $US. This has produced a huge saline drainage surplus from tubewells and open and tile drains. Even then the present strategy is unable to cope with the salt load from canal flows and tubewells. To feed the burgeoning population of Pakistan, an increase in production could be envisaged through increasing the yield of already productive land or through more extensive use of marginal or presently unproductive lands by employing saline agriculture technology, a technology for the economical utilization of salt-affected soils and waters by growing salt-tolerant crops, forage shrubs and tree species, and adopting site specific agronomic management practices. The paper will emphasise the suitable and profitable revegation technology for the cultivation of unproductive salt-affected lands.

The population of Pakistan is 130 million people with an annual growth rate of over 3%. The expected deficit in the supplies of food items in the future is alarming (Table 1). Apart from this Pakistan imports 47% of its timber requirements. This situation warrants immediate measures to meet the challenge.

Table 1. Difference in supply and demand of agricultural products (M tones)

	Supply (1986)	Demand (est. for 2000)	Apparent deficit
Wheat	11.60	18.20	6.60
Oil seeds	0.44	1.97	1.53
Milk	12.70	23.00	10.30
Meat	1.82	2.63	1.50

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2. Salinity Problem

2.1 Extent and nature of salt-affected soils. The total area of Pakistan is 80.5 million hectares (mha) out of which over 20 mha are cultivated. About 16.2 mha of this is irrigated, of which canals irrigate 11.42 mha and the rest is irrigated by tubewells and other means (Govt. of Pakistan 1988). The salt affected area is about 6.3 mha which is mainly confined to the irrigated parts of the Indus Plain (Khan, 1993). According to Muhammed (1973) about 81.0% of the salt-affected soils of the Punjab are saline-sodic or sodic and the rest (19.0%) are saline, whereas 50.7 % of the salt-affected soils of Sind are saline-sodic or sodic and 49.3% saline.

2.2 Causes of salinization. Poor management of irrigation systems (over irrigation and leakage from irrigation canals which raises regional water tables and draws salt to surface soil) and related irrigation practices has led to secondary salinization which is the result of either (a) accelerated redistribution of salts in the soil profile due to high water-tables or (b) the use of insufficient water to leach salts out of the soil. In the latter case, soils are only wetted to a certain depth. Water from tubewells contains variable amounts of salts and their injudicious use has contributed significantly to salinization. In addition, shallow underground water can cause the salinization of surface soils either after periods of capillary rise or when a fluctuating water-table reaches the soil surface. According to International Commission on Irrigation and Drainage (ICID, 1991), 7500 million tones (Mt) of salts are present in the upper 100 meters of the groundwater reservoir of the Indus Plain while about 50 Mt of salts are added to the system every year through the canal irrigation water. Only 10-15 Mt of salts are exported out of the system every year, mainly in the summer flows to the sea below Kotri Barrage. If subsurface drainage is provided to all the irrigated areas of the Indus Plain, the drainage effluent shall pick up 100 Mt of salts every year. Out of this 20 Mt/year would be immediately returned to the land by the recycling of the fresh ground water discharges and 80 Mt/year would remain requiring disposal. On the completion of Left Bank Outfall Drain (LBOD) 25-30 Mt of salts shall be exported from the system to sea every year.

2.3 Reclamation and other aspects. Soil scientists are well aware of the information that is available in reports, research articles, books etc. on various aspects of soil reclamation. Very recently an attempt has been made to compile the work done in Pakistan on reclamation and management techniques for salt affected soils (Ahmad, 1996). Here the experience of revegetating abandoned salt-affected lands of Satiana (Punjab province) is highlighted

3. Revegation Programme for Salt-affected Soils of the Satiana Area: A Sustainable System To Redevelop Salt-Affected Soils

3.1 The Satiana area. The Satiana area is located at a distance of about 20 km from Faisalabad and covers 26863 hectares of land (see map). Approximately 48% of farmers have less than 2 hectares each and 39% have between 2 and 5 hectares. Approximately 55% of the area is salt-affected. About 17% and 12% of the farmers have up to 25% and 25-50% of their land, respectively as totally abandoned due to salinity. The soils are typically saline or saline sodic in nature. Loss in income because of salinity is estimated at 62%(Qureshi and Aslam, 1997). A multidisciplinary task force consisting Soil Scientists, Livestock Scientists, Social Scientists and Forestry and Range Management Specialists was organized to collaborate in research on a voluntary basis. The pivotal role of contacting and motivating the farmers was played by the staff of the Agriculture Extension Service, Satiana, Agriculture Extension Wing of the Department of Agriculture, Govt. of the Punjab. Farmers were encouraged to share the cost of the project by preparing their land, planting seedlings, irrigating and looking after the plants after planting. Farmers' days were organized by the Agricultural Officer in collaboration with the Welfare Association of Salt Land Users (WASLU) and University of Agriculture, Faisalabad to motivate and guide the farmers for revegetation of the salt-affected lands. Seedlings of *Eucalyptus camaldulensis*, *Atriplex amnicola* and *Atriplex lentiformis* were made available to the selected farmers at their fields. So far, 285 highly salt-affected hectares have been planted under

Eucalyptus camaldulensis and 14 hectares under salt bushes in the project area. To enable the local farmers to meet their own requirements and make the activity more sustainable, selected farmers are being encouraged to develop nurseries on a commercial basis. The nursery growers are provided training and technical help by the experts involved in the project. Besides the plantation of trees and forage shrubs, farmers were also motivated to restore agricultural activities on moderately salt affected and patchy salt affected lands by growing crops. (see Table 2). As a result more than 41 hectares were further redeveloped by growing salt tolerant varieties of wheat, rice and sugar cane. Site specific agronomic measures and judicious use of plants nutrients were made to improve productivity. As the soils of the Satiana area are mostly saline sodic, these demand application of gypsum for rehabilitation. About 210 hectares of the area were made productive by applying gypsum to improve Ca: Na ratio of the soil system. All these practices resulted in the substantial improvement in crop yields.

Table 2. Selected salt tolerant varieties/species

Wheat/ Barley	Rice	Cotton	Oil seeds/	Grasses/fodder sorghum	Sesbania	Salt bush
Blue Silver	IR-9	NIAB-78	Ghobi Sarsoon	*Leptochloa fusca*	CB-2	*Atriplex amnicola*
LU-26S	KS-282	NIAB-82	**Sorghum**	*Echinochloa crusgalli*	CB-8	*Atriplex lentiformis*
SARC-1	NIAB-6	MNH-93	Milo	*Elusine coracana*	BA-6	
SARC-2			J-263	*Panicum turgidum*		
SARC-3			**Sugar cane**	Amphiploid-158		
SARC-4			SpSg 26	Rye grass		
Barley			SpSg 394	Mott (MT)*		
PK-30132				Rhodes grass (MT)*		
PK-15869				Buffel grass		

*(MT) Moderately tolerant; Source: Qureshi et al. (1990); Aslam et al. (1993)

3.2 Welfare Association of Salt Land Users: WASLU. To sustain the momentum of the progress and ensure participation by the local community, a Welfare Association of Salt Land Users has been organized which is expected to take over entirely the responsibility of revegetating the salt land in the area. The Association is also an important source of feed back about the strengths and weaknesses of the programme. At present over 135 farmers are its members. The Association is still at an early stage of development and has limited resources to undertake any major projects. However, it has plans to develop its own nursery stocks, acquire agricultural implements for planting trees and shrubs and develop a marketing system for major products.

3.3 Advantages of the revegetation approach

1. About 550 hectares have been redeveloped by using revegetation technology and areas presently declared as waste lands due to the high salinity or sodicity (2-3 mha) can be made productive.
2. Reclamation cost in this case is zero. Therefore the approach is much more cost effective in terms of initial investment.
3. No heavy machinery is needed and the implementation may be phased down to an hectare level, thus there is no dependence on big foreign loans etc.
4. Pressure on the already scarce energy resources of the country for managing water will not increase significantly. On the other hand energy is being fixed in the form of vegetation for reuse.
5. The approach can easily complement the existing engineering approach, in which case the efficiency of the latter will increase many fold.
6. The approach will have a salutary effect on the physical environments of the countryside. The return of waste land to productive uses could be seen as a potent symbol of environmental hope and rural renewal.

7. The salt-affected lands are expected to improve over time rather than deteriorate as at present. The shading effect and root development of vegetation will help in this connection while the high transpiration by species like Eucalyptus greatly helps in controlling the watertable.
8. Socio-economic circumstances of the poor farmers will improve greatly. Farmer should start getting economic returns after 1-2 years from crops and forage species, and 5-7 years from trees grown in the waste lands. A simple cost analysis of tree plantation in an experiment at the Uchkera farm of University of Agriculture, Faisalabad is given in Table 3.

Table 3. Economic returns from different tree species grown under saline-sodic soil conditions, (ECe = 14-41 dS m^{-1}, SAR = 12,6-173).

Name of spp.	Wt. of wood (kg $tree^{-1}$)	Price of single plant (Rs.0.50 kg^{-1} timber)	Return from one hectare (2471 trees)**	Gross return per annum (Rs.)***
Leucaena leucocephala	90	45.0	111195	14826
Terminalia arjuna	35	17.5	43242	5766
Pongamia pinnata	38	19.0	46949	6260
Parkinsonia aculeata	21	10.5	25945	3459
Albizzia lebbeck	99	49.5	122314	16309
Acacia nilotica	150	75.0	185325	24710
Eucalyptus camaldulensis*	201	120.0	296520	39536
Ziziphus jujuba	32	16.0	39536	5271
Tamarix aphylla	35	17.5	43242	5766
Prosopis cineraria	52	26.0	64246	8566

* = Price is Rs.0.60 kg^{-1} timber
** = 2471 plants were planted per hectare.
***= Expenses for protection, uprooting, cutting, transportation, rent of land, etc., are some for each species and may be subtracted for calculating the net income.
Source: Qureshi et al. (1993).

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Possibility of Large Scale Afforestation in Arid Lands as a Measure against Increases in CO_2 Concentration

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Abstract—Global warming is a serious environmental problem. To address this,attention is now being paid to afforestation. Afforestation is suitable in devastated lands such as deserts.

This paper suggests the necessity for deciding proper areas for afforestation, when conducted in arid lands. Effects of techniques introduced in the classified areas is estimated.

Key Words: Afforestation, Classification, region

1.Introduction

Global warming and the increase in atmospheric CO_2 are extremely important environmental issues. Possible counter-measures to these problems include controlling or decreasing exhaust emissions as well as increasing the absorption of CO_2 through the afforestation of devastated lands, such as arid areas. Were 10000km^2 of arid land to be afforested, to the degree of density of temperate forest, 1% of the carbon emitted by human activity each year could be absorbed.

As a research site, Leonora in Western Australia was chosen because of its arid areas. Using resource information about geography, meteorology, hydrology, soil physics, soil chemistry and ecology, we examined and considered the following:

①Present conditions concerning atmosphere, water, soil and vegetation

②Site classification based on standards explained later, for determining suitable afforestation areas

③Consideration of the effects of water collection techniques on the research site

④ Development of a plan to improve atmospheric soil and water resources

2.Outline of Features in Research Site

The research site is Located at latitude 28° 53 'S and Longitude 121° 45' E. The width of the site from east to west is 150km, the length from north to south is 110km. It has a total area of 16500km^2. The features of the site are as follows:

① Long term mean annual rainfall is approximately 222mm.

② Variability in rainfall and temperature, annual, monthly and regional, is great.

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attention: Abe, Yamada & Kojima are the members of the Committee of Biological CO2 Fixation.

Per rainfall precipitation amounts are unpredictable.

③The vegetation in this area absorbs water from the small amount of rainfall and surface runoff after rainstorms.

④Iron concentrations tend to be low in surface soils due to very low organic matter content. On the other hand, the salt concentrations are high in some zones, causing serious problems in these areas.

⑤Infiltration capacity of surface soils is larger than in other areas because the void ratio of surface soils in accumulated layers is higher than that of lower layers. This leads to the formation of underground water in shallow levels, and is useful for vegetation growth.

⑥The rate of vegetation growth differs throughout the site. Rapid growth occurs under good conditions.

Based on this research information and the differences in plant growth, we tried to determine the factors affecting plant growth and to classify the site by land condition.

3.Plant Growth Requirements and Afforestation Area Determination

Table 1 The areas and the ratio of each category in each map

The map classified by contour

	ratio of area (%)	area (km^2)
above 500m	8.0	1,320
450~500m	27.0	4,455
400~450m	42.0	6,929
below 400m(except salt lake)	21.5	3,548
salt lake	1.5	248
total	100.0	16,500

The map classified by soil salinity

	ratio of area (%)	area (km^2)
high soil salinity	18.5	3,052
middle soil salinity	9.1	1,502
low soil salinity	72.4	11,946
total	100.0	16,500

The map shown ease of afforestation

category(condition of water, salt)	ratio of area (%)	area (km^2)
A(○, ○)	13.0	2,145
B(△, ◎)	32.8	5,412
C(◎, ×)	1.5	247
D(×, ◎)	52.7	8,696
total	100.0	16,500

There are three main requirements for plant growth in this area.

Firstly, abundant soil moisture must be present. Obtaining this moisture depends on the concentration of surface runoff in the area. If rainfall is uniform, vegetation at inflow areas uses more rainfall than vegetation at outflow areas.

Secondly, soil salinity does not reach high concentrations. Excessively high salt concentrations prevent vegetation growth.

Thirdly, ample soil accumulation is necessary. Water volume maintained in accumulated areas is greater than other areas. Therefore good growth conditions for vegetation results. Vegetation using this water tends to root deeply, and growth rate accelerates when roots reach the water table.

We classified the site according to the above requirements. First, a contour map was drawn. Because surface runoff flows downward, it is thought that the volume of water pooling in low ground is more than that in high ground. Second, a salinity map was drawn. The areas and the ratio of each category are shown in Table 1.When the contour map was overlaid upon the salinity map, it was evident that salt accumulates in low elevation areas which is where water accumulation also occurs. To address this problem, a .Land System Map. containing a .Vegetation Condition Rating (VCR). was referred to. According to this map, vegetation growth is better in saline than non-saline soils. Therefore it is thought that vegetation growth is more affected by the soil moisture than by salt concentration. Upon consideration of VCR, areas which seemed most suitable for easy afforestation were determined (see Figure 1). This zoning map was classified into 4 parts: Part A is where the salt lake and

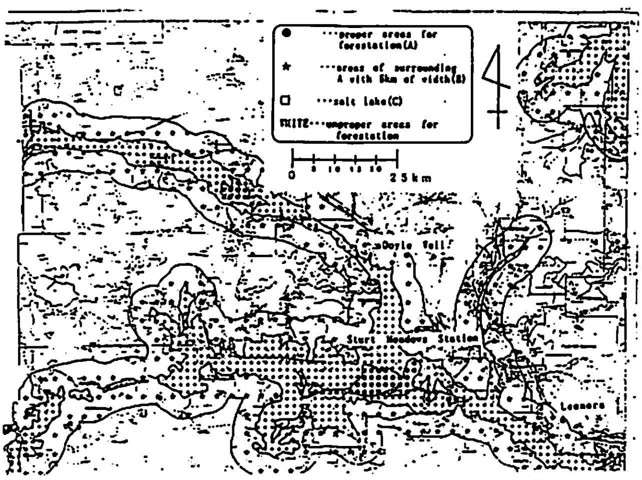

Figure 1 Zoning map shown suitable areas for easy afforestation

the low vegetated places are removed from areas of high soil salinity. Part B, 5km in width, surrounds Part A. Part C is the salt lakes. Part D consists of the other areas. The areas and the ratio of each category are shown in Table 1.

A is areas in which water flows in, therefore it is estimated that plant growth rate is very high. Water collection techniques, for example earth banks were introduced in the site, and these banks affected 5km around A. These areas were thus called B. B areas were lower in soil salinity than A. C areas are those in which water concentrates in quantity, but the concentration of water and salt in soil is too high. If good control of surface runoff and techniques to remove salt from soil are employed, C would be a good area for afforestation.

4.Effect of Precipitation Usage in Zoned Areas

Aims of classification are not only to judge which areas in the site are best for planting, but also to know how best to use water resources. Rainfall is minimal in the area. There is a great possibility of failing if the entire site is afforested. Therefore we think that afforestation should be done only in suitable areas, and the other areas should be used as zones for gathering water and for power generation plants. If A, 2145km², is afforested, area C becomes a downstream area and only areas B and D, 14100km², are left for water gathering. The volume of precipitation(P_r) per year in the water gathering area is $3.13\times10^9m^3$. Supposing that runoff(R_o) is 70% of precipitation, the volume of inflow(I_f) to A is $2.19\times10^9m^3$. If earth banks are introduced in A and stop some percentage of runoff from A, the volume of water resource in A will become larger than before the improvement. Improvement effects are shown in Figure 2.

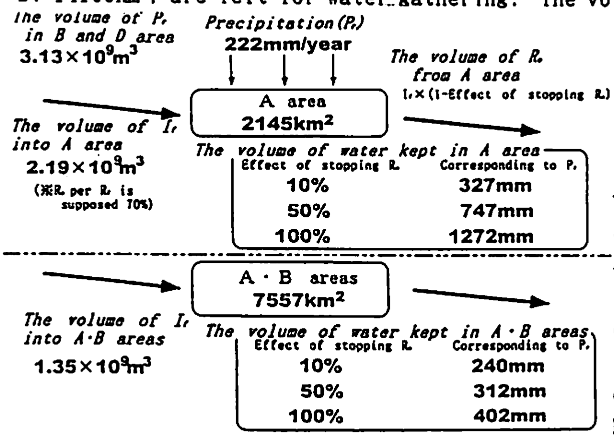

Figure 2 Effect of stopping runoff

When 10% of inflow to A is used efficiently, the volume of water kept in A is equivalent to 105mm of precipitation. Consequently the water resource in A is equivalent to 327mm rainfall because of 222mm rain in A. In the same way, efficient usage of 50% and 100% of inflow correspond to 747mm and 1272mm rainfalls.

If afforestated sites are A and B, and water is gathered in the same way, the combined areas of these is 7557km^2 and water gathering area is 8696km^2. The volume of inflow to A and B is 1.35×10^{9}m^3, and efficient usage of 10%,50% and 100% of inflow correspond to 240mm,312mm and 402mm rainfalls ,respectively(see Figure 2).

Afforestation in suitable areas is many times more efficient than in unsuitable areas. This is why classification of the research site is needed.

5.Conclusion

The following points were clarified by understanding environmental conditions and suitable area designation.

①Minimal precipitation occurs. Post precipitation runoff concentrates in some areas more than others because of topography. Areas of water accumulation are good for vegetation growth.

② Soil erosion and salt concentration also affect vegetation growth. However, water scarcity is the main factor to prevent vegetation growth. Higher the water availability, higher the plant growth rate.

③ Suitable area determination for afforestation is necessary. The site was classified into four areas based on vegetation growth ability as indicated by VCR, contour and salt concentration maps.

④If techniques such as making earth banks are introduced in only A, it is conceivable that a volume of water can be supplied to plants in the areas by efficient usage of runoff. And the water volume is ample enough to enrich present ecosystems in the site.

We could overlay only two maps. One was a topographical map, and the other a soil salinity map. However factors influencing plant growth rate are not limited to only these two factors. It is thought that each influencing factor has either a positive or negative effect on plants. Therefore addition of good factors and subtraction of bad factors is necessary to select suitable areas for afforestation.

The following information is needed to advance this study based on the above. (1) movement of surface and underground water, (2) botanical maps in consideration of carbon fixation, (3) effects of improvement techniques. The collection of these is a future theme, and an afforestation plan including these needs to be contrived.

Acknowledgment

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Role of PV Technology in the Greenification of Arid Land in Nepal: An Assessment

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Abstract - The forest resources of Nepal are highlighted. The reason for rapid deforestation is given. The existing photovoltaic water pumping system for water supply and irrigation in different parts of Nepal is described and related technical problems in the electronic circuits, pumps and repair and maintenance are analysed. Application of PV technology for the greenification of arid land and semiarid land in Jhiku Khola watershed in the midhills of Nepal with relevant data is given. The early actions to be taken at different levels of committees for the greenification of arid land in Nepal are highlighted.

Key Words: Greenification, PV Pumps, Balance of Systems

1. Introduction

Nepal has 5.5 million hectares of natural forests, which is 37% of its total land area. Along with agriculture, forestry plays an important role in the economic and social life of the rural people, who comprise more than 90% of Nepal's population. The share of forestry in the GDP is about 15% [1]. Fodder from forest land provides more than 40% livestock nutrition. Forest litter and dung is relied upon to enrich farm soils. About 1.36 million full time jobs are provided by the forestry sector [1]. The country's main energy source, 70% of the total energy used, is fuelwood from forests, shrublands and lands adjacent to farms. Forests' watersheds are the main source of the water that is needed for energy, irrigation and household supplies.

The increasing population, its demand for fuelwood and timber, the maintenance of large numbers of livestock, lack of political commitment, and scarcity of agricultural land have increased pressure on forest degradation and destruction leading to ever worsening environmental and socio-economic conditions in the country.

The constant loss of agricultural land in the mountain region, due to land slides, leads to another round of deforestation. Despite these facts reforestation programs have taken place on a small scale so far. The average rate of reforestation has not yet exceeded 15,000 hectares per year, which is considerably less than the forested area lost every year [2].

The greatest concern of those involved in reforestation is related to water shortages for growing plants. At some places lack of water results in the loss of over 60% of young plants within the first dry season after planting. New water conserving technologies, such as sprinkler or drip irrigation, are needed in order to utilise effectively this scarce resource. Efficient and economic ways of utilising solar energy could lead to effective afforestation of arid and semi arid land programs[3].

Solar PV pumps, which have been utilised to provide water for reforestation, are being extensively used in difficult topography where other traditional methods of watering are not effective.

2. Solar PV Water Pumping

The existing solar photovoltaic water pumping systems for water supply and irrigation in different parts of Nepal are shown in Table 1.

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Table 1. Solar PV pumps in Nepal

S/N	District	Place	Capacity kWp	Purpose	No. of family benefited	Present Status
1.	Pyuthan	Swargadwari	1.48+0.47	DW, L	NA	Working
2.	Morang	Letang	1.60	I	12	Dismantled
3.	Nawalparasi	Agauli	1.60	I	20	Not working
4.	Surkhet	Bamekhola	1.60	I	22	Not working
5.	Surkhet	Birendranagar	1.48	I	25	Not Working
6.	Dang	Ghorahi	1.48	DW	50	Working
7.	Kathmandu	Sundarighat	4.00	DW	NA	Working
8.	Bhaktapur	Bode	40.00	DW	NA	Working
9.	Tanahun	Chisapani	0.20	DW	50	Working
10.	Siraha	Bhulke	1.40	DW	100	Working

There are altogether ten systems existing in Nepal as shown in Table 1. The oldest system was installed in 1988 in Dang District. A broad survey of their performance, operation and maintenance, outputs and many other related aspects was made during field visits to the sites of solar pumping. This is done through a set of questionnaires including all aspects related to the success or the failure of solar pumping. All the systems installed so far were obtained either under research grant or grant assistance. The common configuration of the systems is array-invertor-a.c. submersible Grundfos pumps. In most cases 25% of the cost of installation of irrigation systems was shared by farmers' community. 75% of installation costs of systems in Argauli and Birendranagar were subsidised by Agricultural Development Bank of Nepal. Systems installed solely for irrigation (I) purpose are not in operating condition while those installed for drinking water (DW) supply and lights (L) are in operation. One system installed in the remote temple of Swargadwari is not operating optimally.

The most common technical troubles were observed with invertors while in two cases problems with pumps were observed. Photovoltaic modules themselves were found to be the most reliable part of the system as none of the sites have had any trouble with the modules.

Some of the important operational characteristics indicate that two of the community based systems failed while the third is not in good working condition. This indicates that there had been mistakes in the approach of implementation as well as operation and maintenance in the community based pumping system.

Operation and maintenance of the systems are quite successful and well organised in three sites where institutional involvement is present. In one of the community based irrigation systems operation approach was appropriate but it had problem with source of water, while in the next case there was a problem with security and lack of technical capability.

<u>Problems Experienced in Field</u>

The major problems experienced in the solar PV pump sites are as follows:

- lack of involvement of beneficiaries at the project perception level;
- incapability of farmers to handle simple repairs;
- lack of proper approach of operation and maintenance of community based systems;
- lack of institutional interest in successful operation;
- lack of technical support at the time of need;

- lack of institutional framework for solving the problems identified;
- lack of trained manpower at the local level;
- lack of proper site selection and design approach;
- lack of data on water table.
- lack of commercial interest; and
- lack of awareness among people.

Solar PV water pumping systems in some cases have failed to provide a reliable service, mainly because of mistakes made at project inception level. Most of the problems experienced in the field could have been avoided with a systematic approach starting from the project perception to the operation and maintenance level. The following are some solutions to the problems experienced in the field:

- include operation and maintenance as an integral part of project cycle;
- involve the users community right from the beginning of the project planning not only during the phase of operation and maintenance;
- increase the technical capability of the user community giving introductory training;
- develop institutional framework to patronise solar pumping systems;
- use an appropriate operation and maintenance;
- use engineering principles and practices for designing the system and not guess;
- make necessary policy level changes to support the promotion of technology; and
- provide technical support at the time of need.

With improvements as mentioned above, PV pumps could be used for irrigating arid or semi arid land.

3. Rehabilitation of Denuded Land

Uses of solar PV pumps in the Jhiku Khola Watershed [4] have become quite useful. The plant nursery, which is an integral part of the rehabilitation project, demands a regular supply of water to maintain seedlings and cuttings of various nitrogen fixing trees and grasses. During the dry periods (December-May), water shortages are acute and a regular supply is essential, especially to the transplanted seedlings which quickly reach wilting point. Andheri Khola rivulet is the only water source but it is about 200 meters away and about 35 meters below the nursery. The project introduced two solar pumps to lift stream water on a step basis to the nursery and transplanting areas. Water is collected in drums at different sites, minimizing the water transport required.

The operational capacity of the first pump is lower than that of the second. The first pump uses 80 watts and deliver 150 litres of water per hour over a vertical lift of 20 meters. The technical details of pumps and panels are provided in Table 2. The difference in water delivery is associated with the efficiency of the pumps.

To meet water requirements, the pumps operate afew hours daily lifting an average of 700-900 litres per day. Water efficient techniques such as trickle and sprinkle irrigation are applied to off-season crops namely capsicum, water melon, cucumber and strawberry, as well as to fruit trees(mango, lychee etc.).

4. Early Actions for Greenification

Photovoltaic water pumping eliminates fuel dependence and reduces operation and maintenance costs. This is advantageous in developing countries where the fuel price and inflation rate are high.

The involvement of local people, entrepreneurs, volunteers, NGOs, community associations, women's groups, cottage industries, temple groups, school teachers, cooperatives should be encouraged in the promotion of this technology.

Table 2: Technical Aspects of Solar Pump Installation

	Panel Specifications	
	Pump A	Pump B
Manufacturer	Siemens	Siemens
Rated Output(W)	40	48
Voltage (V)	12	12
No. of panels	2	1
	Pump Specifications	
Manufacturer	Flow Light	Minnesota Electric Technology
Vertical Lift (m)	12.23	20.4
Discharge (l/min)	2.5	4.6
Installation Date	March 1994	November 1994

The early actions to be taken at various levels of development committees for the mass application of photovoltaic technology for the greenification of arid land in the Himalayas of Nepal are as follows:

- create awareness of this technology by providing the opportunity to observe successful solar PV water pumping system;
- create awareness of this technology and guide the above groups to possible sources of funding; and
- linkage with PV promoters with regionally based industry representatives and solar energy support agencies.

5. Conclusions

The analysis of the installed small solar photovoltaic water pumping systems for drinking water, irrigation and direct watering to grow vegetation on arid/semi arid land indicates that solar pumping is technically viable when a little care in operation and maintenance is provided.

The potential of solar energy should be further investigated at a practical level, including study of its economic impact on greenification of arid/semi arid land.

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RESEARCH, DEVELOPMENT AND ITS IMPACT ON WATER MANAGEMENT AND FARM PRODUCTION

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Abstract - Pakistan is basically an agricultural country, therefore agriculture plays a central role in economic development .Out of 79.61 mha (million hectares) of the country surface area, only 21.46 are available for agriculture. The Indus Basin irrigation system irrigates 14.0 mha of land out of 17.12 mha of the total irrigated area in the country. Low irrigation efficiency of 34% in the Indus Basin has resulted in problems of waterlogging and salinity on about 40% of the land on the one hand and shortage of irrigation water on the other hand. Rainfed areas of Pakistan comprises of about 5 mha, which is about 25% of the total cultivated area of the country. The rainfall in these areas is erratic and uncertain. One of the major constraints for sustainable agriculture in these areas is absence of assured irrigation supplies. Research and development efforts have been made in the country to deal with the limitation stated above. This paper presents the salient outcomes of various research and development endeavors and its impact on water management and farm production.

Key Words: Water losses, Low irrigation efficiency, Research and Development, Water saving, Impact on Farm production.

1. Introduction

Pakistan has an extensive irrigation network and the Indus Basin is the world's largest irrigated plain. It is fed by the waters of the Indus river and its tributaries. The salient features of the system are three major storage reservoirs, namely Tarbela and Chashma on the river Indus and Mangla on the river Jhelum; 19 barrages, 12 inter-river link canals and 43 independent irrigation canal commands. The total length of main canal is 58,500 km, whereas about 10,000 water courses comprising of another 1,621,000 kms convey irrigation water from the canals to the farmer's field. The average annual flow available in the Indus Basin river is approximately 17.65 million hectares meter (mhm). The average annual river diversions to the canal system are near 12.96 mhm. The estimated losses in the canal system are assumed to be 25% which leaves 9.75 mhm available to the water course command area. However, within the watercourse commands, approximately 294,000 public and private tubewells provide an input of approximately 4.07 mhm, making 13.83 mhm available at the head of the watercourse.

The important technical problems which are hampering the efficiency of farm water management are i) losses of water in the conveyance and distribution system ii) unequal distribution of water with farmers at the head of the system receiving excessive supply at the expensive of downstream farmers iii) main system design not sufficiently based on realistic farm water demands iv) unreliable or untimely supply of water to the farm v) poorly graded and badly shaped plots and vi) poor irrigation practices. The adverse effects of these factors are i) waterlogging and salinity ii) reduced benefits from agricultural inputs iii) food production below potential level iv) reduced benefits of investments to the farmers.

2. Summary Of Research Findings

During 1973-75, the water losses studies were conducted on farmer's watercourses, which indicated average watercourse conveyance losses of 45-47%. These findings resulted in the development of "On-farm Water Management Programmes" in the provinces with major emphasis on watercourse improvement. Research studies were conducted to develop low cost improved earthen watercourses, control structures and lining techniques which are now part of the watercourse improvement programmes.

The water application losses at field level range from 25-40% mainly because of non-levelled fields and flood irrigation. The precision land levelling in sodic soils using laser levelling technique increased crop yield by 70% and 30% for rice and wheat respectively. The precision land levelling also provides better drainage of excess water during monsoon season. The precision land levelling is now a part of the "On-farm Water Management Programme" in the country.

Irrigation requirements in relation to moisture stress have been worked under field conditions for major field and horticultural crops in the major agro-climatic regions of Pakistan. The results showed that delayed irrigations

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during rainy season helped utilized the rain water effectively and avoid the problems of surface ponding. Higher moisture stress at 75-90% depletion of available water helped increased yield of cotton, sorghum and gram crops. The water use efficiency of wheat, sugarcane and maize crops can increased by irrigating at 75% depletion of available water instead of 50%. Irrigation scheduling models have been developed for surface irrigation especially the management strategies for less flexible and continuous flow irrigation system in the Indus Basin. These models are now being tested for wheat crop in farmers fields in "Command Water Management Programme" of Punjab province.

The research on irrigation methods indicated that planting of wheat on ridges and broad beds increased yield by 25% with 30% saving in water as compared to basin planting. Development of appropriate machines of ridge or bed plantings and furrow irrigation for large scale adoption by farmers are thus receiving priority.

Low cost sprinkler irrigation systems have been developed for small farms of upto 2 hectares by using the locally available rainguns, multi-stage pumps and diesel engine or electric motor. The cost of these systems ranges from US$ 400-500 per hectare. The supplemental irrigation for wheat crop in rainfed areas resulted into 2-3 fold increase in wheat yield. The cost of sprinkler systems can be recovered within two years. Locally made trickle irrigation systems have also been demonstrated for fruit orchards. The use of modified furrow irrigation for fruit orchards in coarse textured soils indicated 5-6 times savings in water compared to flood irrigation.

3 Implementation Of Development Programs

The Government of Pakistan with the assistance of US Agency for International Development (USAID) launched an "On-Farm Water Management (OFWM) Development" pilot project during 1976-77 and was extended in Pakistan on its success. The components of OFWM program are watercourse improvements, promotion of precision land levelling, introduction of improved farm layouts, and propagation of advance irrigation agronomy practices. The program functions are implemented with the active participation of the farmers by organizing them into Water Users Associations (WUAs). The components of OFWM Program are discussed as follow:

3.1 Water Users Associations. The WUAs, organized under the pilot project, could not meet the desired goals, particularly operation, maintenance and recovery of costs. Therefore, a Water Users Association Ordinance was promulgated during 1981 for the effective implementation of subsequent OFWM Projects. The WUAs were assigned responsibility prior, during and post watercourse improvement periods. These organizations have played a vital role in proper cleaning and maintenance for the improved watercourses. The farmers participation has reduced the administrative and logistic burden at the farm level irrigation. It has promoted local leadership for better utilization of saved water through watercourse improvement.

The WUAs undertake earthen improvement entirely themselves. The WUAs arrange labor required for improvement of watercourse, settle disputes amongst water users in respect of alignment of watercourse, fixation of naccas, and distribution of works etc. WUAs carry out civil works under their direct supervision with technical assistance of the Water Management field staff. The association are also responsible to undertake the post improvement O&M activities. It is estimated that beneficiaries bear almost 50% cost of watercourse improvement and entire cost of post improvement O&M. Idea of organizing the Water Users Association for watercourse improvement is to create a sense of participation, possession, and ownership amongst the farmers.

3.2 Water Course Improvement. Watercourse improvement is the most important component of OFWM Program. Watercourse improvement involves earthen renovation of main channels including its branches (community watercourses) by demolishing and rebuilding with clean, compacted soils: partial lining of weak or sandy sections: installation of naccas: and construction of other water control structures such as culverts, drops, syphons etc., for improvement of its conveyance efficiency. The water users provide all the unskilled and semi-skilled labor for the earthen reconstruction as well as the masons, required for construction purposes. However, 25 percent of cost of the material is recovered from the water users in 10 installments over five years with a two-year grace period. Brick lining up to 15 percent of the total improved length of the watercourse in fresh groundwater zones and 30 percent in saline areas is intended to minimize water losses. There are about 100,000 watercourses in Pakistan and nearly 21,000 watercourses have been improved so far. At present, nearly 3,000 watercourses are being improved annually due to funding constraints.

3.3 Precision Land Levelling. Precision land levelling was launched as one of the components in the OFWM pilot project. Farmers were provided subsidy up to 50% cost involved for carrying out precision land levelling of their fields under these schemes. Later on, though, subsidy was slashed in successive OFWM project, yet it remained an integral part of OFWM technology package. The OFWM projects provided technical assistance to the farmers in surveying, planning and designing while farmers bear entire cost of physical operations. The project also provides land levelling equipment to the farmers on rental basis.

Recently, LASER technology has been introduced under OFWM. About 140 LASER levelling units have been acquired by OFWM from different sources. Various research studies have indicated that precision land levelling and improved field layout can increase the crop yields upto 20 percent.

3.4 Irrigation Agronomy. The techniques pertaining to efficient methods of irrigation were, diffused amongst the farmers both through organizing effective training and by establishing demonstration centers focussing specially on When?; How much?; and How? to apply irrigation water with an optimum combination of rest of the agronomic inputs. The farmers are generally habitual of increasing their cropped area without considering quantum of available water supplies which result in shortage of water in stress periods, thereby adversely affecting crop yields. The concept of water budgeting was thus considered necessary to be introduced amongst farming community.In order to make OFWM techniques popular and well adopted amongst farmers, demonstration centers and farmers are established to strengthen the OFWM Extension Services.

3.5 Land and Water Management under Rainfed Conditions. In Rainfed areas the soils is fertile, climate is favorable for agriculture and there exists great unharnessed potential for agricultural development. Uncertain rains and absence of assured irrigation supplies are among the main constraints for agriculture development. There are certain pockets in rainfed areas which have considerable amount of ground water and other water resources which can be exploited for irrigation purposes. It is, therefore, considered imperative to fully exploit and efficiently utilize available water resources in these areas. Following success of program in canal irrigated areas, OFWM activities have recently been extended to rainfed areas.

3.6 High Efficiency Irrigation Technology. In rainfed areas, where the land is undulating and/or sandy, if provided with efficient irrigation system, have a potential of increasing crop production two to three fold. A low cost Rain-gun sprinkler system has been locally developed and successfully tested by the OFWM Punjab for achieving higher irrigation efficiency in rainfed/water scarcity areas. Four hundred such units have been provided to the farmers in 12 rainfed districts of the province on subsidized rates.

3.7 Water Storage Tanks. The available water sources (agro-wells and perennial streams) in mountainous areas often have small discharges and direct application of these low discharges result in higher conveyance losses. Water storage tanks are being constructed in these areas to conserve water by increasing the volumetric flow through intermittent and timely releases. Water from these storage tanks is conveyed to the point of uses either through the lined watercourses or through small diameter pipes. At some places in NWFP and Balochistan Provinces, drip irrigation system has also been employed for irrigation crops from the water storage tanks.

3.8 Hydra Ram Water Lifting Devices. Locally developed, low cost, and energy-less technology of Hydra Ram Pumps have been introduced in hilly and sub-mountainous rain-fed areas of the country. These devices are installed on natural springs and at perennial as well as non-perennial streams for lifting water to irrigate crops grown in the uplands. The pump runs with the kinetic energy of flowing water and do not require any engine or motor for its operation. On a pilot basis, several Hydra Ram pumps have been installed in the Pothwar area and Soan Valley of the Punjab province for lifting water from perennial streams to irrigate higher lands.

4. Impact Of Water Management Program. Different evaluation studies carried out by various agencies viz Water and Power Development Authority (WAPDA); OFWM Training Institute, Lahore; Implementation and Progress Section of Planning & Development Division, Islamabad and Punjab Economic Research Institute, Lahore. These studies indicate that huge water losses have been reduced due to OFWM improvements. The program has also considerably contributed in increasing the crop yields. The results of different studies on impact evaluation of OFWM projects are as under:

4.1 Impact of watercourse improvement on farm production and economy-study by OFWM training institute punjab, 1979.

-	Increase in delivery efficiency	38.5%
-	Reduction in water losses	28.4%
-	Increase in cropping intensity	19.8%
-	Increase in crop yield	17.5%

4.2 Watercourse losses in Sahiwal Tahsil-study by OFWM training institute Punjab, 1981

-	Reduction in water losses	53%
-	Increase in cropping intensity	14%
-	Increase in crop yield	24.3%

4.3 Monitoring and evaluation of OFWM USAID assisted project study by WAPDA, 1984

		Watercourse Improvement	Precision Land Levelling
-	Increase in delivery efficiency	27%	-
-	Reduction in water losses	25%	-
-	Increase in cropped area	4.5%	19.1%
-	Increase in crop yield	14.8%	18.5%
-	Increase in cropping intensity	5.8%	19.7%
-	Reduction in salinity area	4.9%	42.0%
-	Reduction in irrigation time	-	25.0%

4.4 Socio-economic impact on agriculture production and farmer's income in Sahiwal Tahsil-study by economic study cell, agriculture department Punjab, 1981

-	Increase in cropped area	13.4%
-	Increase in cropping intensity	14.8%
-	Increase in crop yield	13.1%

4.5 Evaluation of on-farm water management program in Punjab - by Punjab economic research institute, planning and development department, Lahore December, 1985

-	Saving water	23%
-	Increase in cropping intensity	9%
-	Reduction in water losses	72%
-	Saving in time and labor	30-36%
-	Increase in crop yield	17%

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Excess Water Disposal using Evaporation Accelerators

Tetsuo OGAWA*, Yukuo ABE**, Tomoharu YAMAGUCHI**,
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Abstract - A new method of removing excess water in arid regions employing evaporative force was experimented. Evaporation Accelerators made of paper increased evaporation rates proportionally to the surface area of the Accelerator and drained water from sand under specific conditions.

Key Words: Excess water, Drainage, Evaporative force, Evaporation Accelerator

1. Introduction

In arid regions, proper disposal of water is necessary to cope with water logging, poor drainage and ponding of waste water. Conventionally, water is made to move to lower levels to drain off. However in some cases this is not always possible to accomplish because of the technological and financial implications of constructing underdrainage systems, etc. Thus a different approach to solving this problem is necessary. In this study, a reformed salt capturing stick (ABE *et al.*, 1992, II *et al.*, 1993) was employed as an Evaporation Accelerator and new methods of draining arid regions were planned and investigated. Methodologically, excess soil moisture is evaporated and radiated into nature by using strong evaporative forces. This report examines the idea, effectiveness and practicality of Evaporation Accelerators as moisture and salt removers from a scientific and commercial perspective.

2. Materials and Methods

2.1 Evaporation Accelerator

Evaporation Accelerators were made of paper (Cooking Paper marketed in Japan by Lion Co., LTD., 275 × 240 mm), because paper is both porous and absorbent. The paper was coiled around a wooden stick. Its length was 400 mm and its diameter was 10 mm.

2.2 Sand

Two sand samples were used. One was pure sand (Toyoura standard sand). The hydraulic conductivity of pure sand with a 1.53 g/cm^3 dry bulk density was 2.1×10^{-2} cm/s. The other sand was a mixture of 95% sand and 5% clay (Kibushi clay). This sand is termed mixed sand. The hydraulic conductivity of mixed sand with a 1.51 g/cm^3 dry bulk density was 2.2×10^{-3} cm/s.

2.3 Test apparatus

Experiments were conducted in pots with an inner diameter of 250 mm and a height of 300 mm.

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The pot was filled with pure water or sand, and was placed in a closed chamber with an air-conditioner, and kept at a temperature of 40°C and relative humidity of 50%. The bottom of the pot was connected to a mariotte's tube for maintaining constant ground water level. A removable chamber to vary temperature and wind velocity was installed on each pot for changing the evaporative conditions of the Accelerators.

2.4 Methods

The pot was filled with pure water, and kept at a temperature of 40°C, a relative humidity of 50% and a wind velocity of 1–2 m/s in a closed chamber. The Accelerators were installed into the pot, and the number of Accelerators were changed from two to thirty-seven. During the experiment, the weights of the mariotte's tube were measured for estimating evaporation rate. The Accelerators were inserted into the pot at a height of 19 cm above the water surface, and a cover was installed on the water surface for protecting against evaporation.

The pot was filled with pure sand or mixed sand, and was kept at a temperature of 40°C and, a relative humidity of 50% and a wind velocity of 1–2 m/s in the closed chamber. Water level was kept 20 cm below surface sand, and seven Accelerators within an inner diameter of 5 cm were installed into the center of the pot at a height of 14 cm above surface sand and a depth of 23 cm. A removable chamber varied temperature and wind velocity and evaporation rate and distribution of water content in the sand were measured for each environmental condition.

3. Experimental results and discussion

3.1 Water evaporation with the Accelerators

Fig. 1 shows the relationships between the surface area of the Accelerators and the evaporation rate from the Accelerators. Evaporation rate increased in proportion to increasing the surface area of the Accelerators up to about 1000 cm^2 (16 Accelerators). Increasing of surface area decreased the void rate in the area of Accelerator installation. A change in void rate from 100 to 95%, decreased the evaporation rate by 5%. A change in void rate from 95 to 85%, decreased the evaporation rate by 10%. Therefore, for a surface evaporation area up to 1000 cm^2, no significant effect on evaporation was seen by increasing the number of Accelerators, however increasing the surface area of the Accelerators greatly increased the rate of evaporation regardless of the void rate.

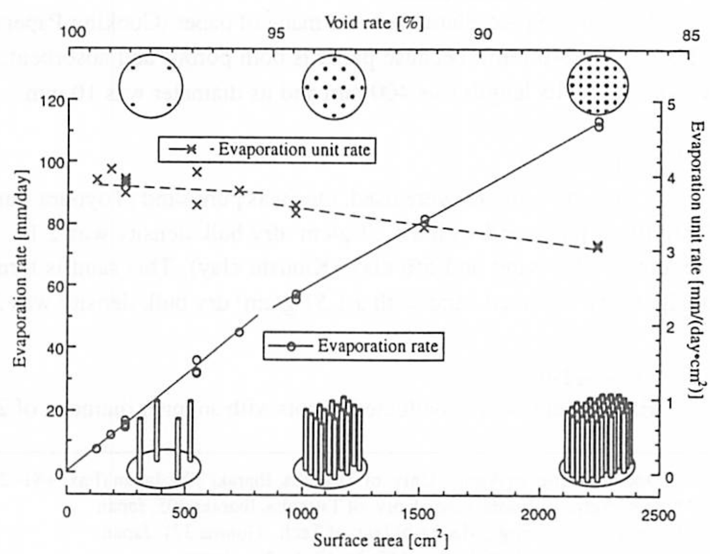

Fig. 1. Changes in evaporation rate for the Accelerators

3.2 Water evaporation from the sand with the Accelerators

Table 1 shows evaporation rates under certain conditions. Evaporation rates depended on temperature, wind velocity in the closed chamber and the removal chamber. The evaporation rate of pure sand with the Accelerators increased with temperature increase. As a result of the evaporation rate, the water removed from the sand by the Accelerators was in proportion to the conditions. Under condition A, the evaporation rate of mixed sand was almost equal to that of pure sand, but under condition B, the evaporation rate was reduced to half.

Fig. 2 shows the change in the water content of the Accelerators at varying heights. Under condition C, water content in the upper section of the Accelerators decreased remarkably and the water content and evaporation rate indicate that the Accelerators were unable to extract water from the sand quickly enough to meet evaporation potential. Consequently, the mixed sand prevented water transport toward the Accelerators by lowering hydraulic conductivity, and reducing evaporation rate.

Table 1. Measurements of evaporation rate under four condition

	Condition	Wind velocity (m/s)	Temperature (℃)	Sand	Evaporation rate (mm/day)
Bare surface	A	2.0	40.0	Pure	10.4
				Mixed	10.4
Using Evaporation Accelerators	A	2.0	40.0	Pure	16.3
				Mixed	14.6
	B	5.7	65.4	Pure	67.9
	C	6.9	61.6	Pure	104.3
				Mixed	53.3
	D	9.1	77.5	Pure	123.9

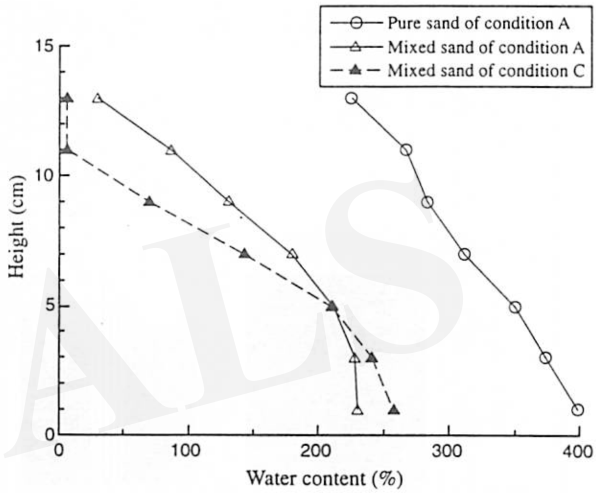

Fig. 2. Changes in water content of the Accelerators

3.3 Distribution of water content in sand

Fig. 3 shows the changes in the degree of saturation for the test apparatus of pure sand. Table 1

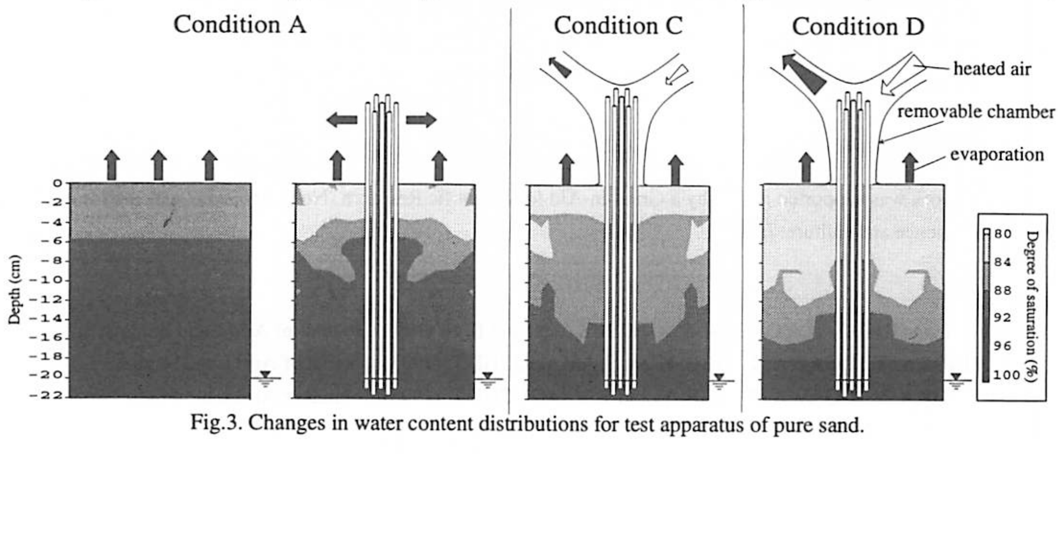

Fig.3. Changes in water content distributions for test apparatus of pure sand.

details the three evaporative conditions of the test apparatus. Under condition A, the water content of the apparatus containing Accelerators decreased more than the apparatus containing only pure sand. Under conditions C and D, water content decreased as it did under condition A. Distribution of water content did not vary during condition A and C, although evaporation rate increased about four times. This was ascribed to constant water transport from the water table to the surface layer by the Accelerators. The behavior of water toward the Accelerators in each layer was minimal. Under condition D, the degree of saturation was less from the mid section to the upper section than under condition C. Change from condition C to D increased the movement of water towards the Accelerators in each layer.

Fig. 4 shows the changes in the degree of saturation for the test apparatus of mixed sand. There were two evaporative conditions for the test apparatuses as shown in Table 1. Under the condition A, water content decreased in the mixed sand with the Accelerators more than in the bare mixed sand, and water content decreased mainly in the sand surrounding the Accelerators. Change from condition A to C did not appreciably change the distribution of water content in the sand because the evaporation rate decreased as stated in 3.2.

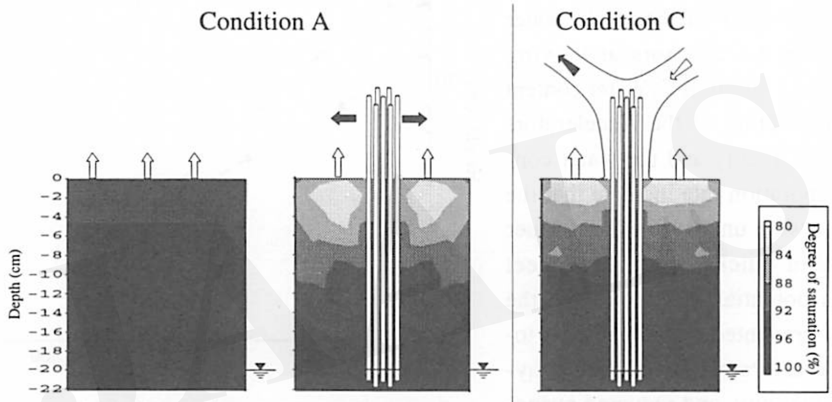

Fig.4. Changes in water content distributions for test apparatus of mixed sand.

4. Conclusion

According to this study, we can conclude that the evaporative drainage method evaporation accelerator promotes evaporation and under certain conditions of replacement it can affect water consistency in sand. It could possibly be used as a new drainage method differing from former methods which used drainage equipment. Further study is necessary to examine a better method to treat the salts which accumulated on the Evaporation Accelerator.

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Reevaluation of sand dunes' mobility indices

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Abstract - Indices of sand mobility are based on precipitation, evaporation and wind magnitude. It is shown that the effect of the rate of evaporation and the quantity of rain is distinct on sand than on other finer soils. For that reason dune sand that gets more than 90 mm of annual average rainfall may be stabilized naturally by vegetation under certain wind regimes. The wind magnitude is an important factor in sand mobility because of the sand uncohesiveness, but it is more effective when used together with the wind directionality factor.

Key words: sand dunes, desert sand mobility, stabilization, vegetation.

1. Introduction

Several wind erosion or sand mobility indices have been developed for various parts of the world (Chepil et al., 1962; Ash and Wasson, 1983; Wasson, 1984; Lancaster 1988). All of them are based on two factors that increase or decrease dune mobility. The first one deals with the degree windiness (expressed as the average annual wind velocity to the third or fourth power, or as the annual percentage of days experiencing winds above the threshold for sand movement). Most dunes will be mobilized if windiness is increased. The second factor is the vegetation growth cover that is taken as a function of the ratio between the average precipitation (P) and evaporation (E). This factor, the widely known Thornthwaite's (1931) "precipitation - effectiveness index" ($P-E$), is obtained by determining the sum of the P/E ratios for each month of the year and multiplying it by 10 to eliminate fractions:

$$P-E=10\sum_{n=1}^{12} P/E \qquad (1)$$

The first use of Thornthwaite's precipitation - effectiveness index for aeolian processes was introduced by Chepil et al., (1962) who derived a wind erosion climatic index, C_1, expressed as a percentage of the average annual wind erosion climatic index for Garden City, Kansas:

$$C_1=100\frac{U^3}{(P-E)^2}/2.9 \qquad (2)$$

where U is the average annual wind velocity (in mph) at a standard height of 10m. Equation 2 was used by Talbot (1984) in the Sahel region to determine that active sand dunes are formed where $C_1 > 10\%$. A transitional zone exists when $5 \le C_1 \le 10\%$, where aeolian activity is limited to coppice dunes and sand sheets. The index of $0.1 \le C_1 \le 1.0\%$ indicates the southern margin of the stabilized dune belt in the Sahel region.

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A similar approach was developed by Ash and Wasson (1983) and Wasson (1984) for the linear dunes and lunetts of Australia. Considering the above equations Lancaster (1988) developed an equation that is based on the same idea:

$$M = \frac{W}{P/PET} \qquad (3)$$

where: M = sand mobility index
W = percent of days during the year with sand moving winds.
P/PET = the ratio of mean annual precipitation to mean annual potential evapotransiration.

P/PET is a similar parameter to the precipitation - effectiveness index (Equation 1) of Thornthwaite (1931). It has been used recently to define drylands for studies of desertification (UNEP, 1992). Equation (3) was used for sand dunes in the Namibia and the Kalahari desert (Lancaster 1988) and in the USA (Muhs and Maat, 1993; Stetler and Gaylord, 1996). The critical values for Southern Africa were $M>200$ for fully active dunes with no vegetation and $M<50$ for inactive vegetated dunes (Lancaster 1988). These values are not in accord with the results from southern California (Bach and Brazel, 1995).

There are several examples of unvegetated active sand dunes in the humid areas of Alaska, Oregon, the Atlantic coast of North America and South Africa (Cooper, 1938; Hunter et al., 1983; Illenberger and Rust, 1988) and vegetated fixed dunes in the arid Negev (Tsoar et al., 1995).

2. Aim of study

The aim of this paper is: (a) to point out the peculiar characteristics of dune sand as a substratum for desert vegetation and soil moisture, that are distinct from all other desert soils, and to show the basic error in using Thornthwaite's (1931, 1948) parameters for desert sand; and (b) to propose a different method of evaluating sand dune mobility which would take into consideration the wind characteristics only.

3. The physical properties of desert dune sand and its effect on vegetation

Thornthwaite's (1931; 1948) parameters are based on two important factors that control the biomass. Precipitation is in direct proportion to the biomass while the potential evapotranspiration is inversely related to it. This may be true for all soils other than sand in desert. Dune sand is known to have high rates of infiltration because of its relatively big pore spaces. As a result sand quickly reaches its field capacity, which is less than 10%. Sand is devoid of runoff and most of the rain infiltrates into the soil. More rain will only leach the sand of its nutrients. Hence, plants on sand need frequent and small inputs of water into the soil for maximal biomass (Tsoar, 1990). Because dune sand offers the feature of easy and deep percolation where moisture is protected from evaporation during the long dry periods, moisture retention is assured in desert sand below the upper 30 cm.

The wind factor in the above equations does not refer to its directionality. A unidirectional wind has a different effect than multi-directional wind although they both may have the same windiness or average annual velocity. Unidirectional wind is known to form barchan or transverse dunes when vegetation is non-existent and parabolic when vegetation exists. The whole energy of the wind on these dunes is exerted on the windward side of the dune. All the eroded sand is deposited on the lee side (slip face). Seif dunes are formed when the wind is bi-directional and star dunes form under multidirectional winds. The wind energy on these dunes is divided between two or more flanks and therefore they will create less erosion per unit area.

4. Wind as a factor for sand mobility

Since sand has on the one hand the best moisture availability in deserts and on the other hand is composed of non-cohesive particles, erosion of sand and not lack of moisture is the primary limiting factor for vegetation on dunes, both in humid and in arid lands (where the average amount of rainfall is at least 90 mm).

The sand transporting power of wind can best be calculated using the technique developed by Fryberger (1979). Potential sand transport is calculated from wind frequency tables (preferably derived from hourly data), and from this the drift potential (DP) is calculated, expressed numerically in vector units. DP is a parameter of the potential maximum amount of sand that could be eroded by the wind during a year. DP, being roughly proportional to the cube of wind speed, is a measure of wind energy. The magnitude of the resultant vector is defined as RDP (the Resultant Drift Potential). The index of the directional variability of the wind is the ratio of the resultant drift potential to the drift potential of the wind (RDP/DP). RDP/DP approaches unity when the wind comes from the same direction and zero when the wind is multidirectional with symmetric distribution of DP for each direction.

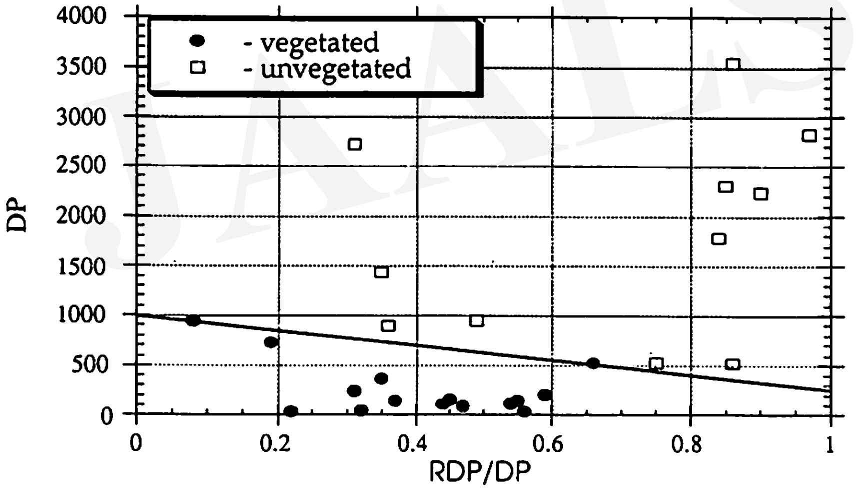

Figure 1. DP versus RDP/DP for 26 stations in areas where the annual average rainfall is ≥ 90 mm. Data collected by the authors, Fryberger (1979) and Breed et al., (1979).

The inference based on field evidence is that rainfall or soil evaporation are not the substantial parameters that affect stabilization or mobilization of sand dunes. The predominant factors are the total annual wind magnitude above the threshold speed (DP) and the annual wind direction variability (RDP/DP). Analysis of wind data from sand dune fields in Africa, Israel and elsewhere (where the annual average amount of rainfall is ≥ 90 mm) gives the relationship of DP versus RDP/DP for vegetated and unvegetated dunes (Figure 1).

Figure 1 shows that unvegetated dunes are of high DP regardless of the amount of rainfall. However, when RDP/DP is low, the wind energy is distributed on more than one slope of the dune and the energy exerted on each slope is lower. For that reason sand dunes with a high rate of directional variability are covered by vegetation on their slopes (as most star dunes) while under the same DP and low rate of directional variability, the dunes are bare of vegetation. According to Figure 1, sand dunes in areas where the annual average rainfall is • 90 mm are unvegetated when:

$$\frac{DP}{1000-750\frac{DP}{RDP}}>1 \qquad (4)$$

5. Conclusions

It is obvious that without rain we would not get any vegetation on sand dunes. However, wind (in the combination of DP and RDP) is the most important factor determining the establishment of vegetation on the dunes and consequently the mobility of the sand in areas that get more than 90 mm of rainfall. Increase or decrease in the precipitation and evaporation would not do as much to increase or decrease the amount of vegetation as the wind DP and RDP/DP. Because of the high rate of infiltration of water into sand, frequent rainfall of relatively small amounts would support annuals while sporadic rain of high intensity, typical in deserts, would bring about infiltration to a depth where the moisture is protected from evaporation and can be provided to shrubs during the long dry periods.

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Construction of Vegetation Systems in the Tarim Oil Field in China

Pan BORONG*, Xu XINWEN*, Hu YUKUN*

Abstract - The Taklamakan Desert, located in the Tarim Basin of Xinjiang, China, is characterized by hostile desert environmental conditions. Research conducted for two years has shown that it is feasible to grow vegetation on desert sands through irrigation with ground water that contains salt at the rate of 4 to 5 g/L. Plastic greenhouses were built and more that 2.5 ha of sand vegetated. Over 60 species of plants for sand stabilization, landscape plants (greening plants), and vegetables were selected for adaptation to the site. In addition 300,000 saplings were propagated in the nursery for desert plantings. This research provides the basis for further research on desert revegetation.

Key Words: Vegetation Systems, Tarim Oil Field, Xinjiang, China

1. Introduction

Tarim Basin, the biggest inland basin in China with an area of $56 \times 10^4 km^2$, is located in the center of Eurasia. Being rich in oil and natural gas resources, the Tarim Basin boasts of calculated resource amount of 191.5×10^8 ton (107.6×10^8 ton oil and $839 \times 10^{10} m^3$ natural gas) and has become the important region for oil industrial development in China (Wang , 1996).

The Taklamakan Desert, which is well known as the Sea of Death is the second largest drifting sand desert in the world. It covers $337{,}000 km^2$ in the center of Tarim Basin. The discover of high yield oil and natural gas wells Tazhong-1 and Tazhong-4 oil in October 1989 and April 1992 indicate that Tazhong (Central Taklamakan Desert) will become an important region for oil and natural gas production.

The completed Tarim Desert Oil Road, runs from North to South for 522km through the Taklamakan Desert, it crosses 446km of true desert. The establishment of this road has hastened the exploitation of oil and natural gas resources in the central desert.Tazhong-4 oil field has the potential of producing 2 million tons of crude oil annually.

It is essential to combat the moving sand and to create more favorable environments for workers during the construction and production stages of the exploitation of the Taklamakan Desert petroleum deposits. Therefore, the establishment of desirable, vegetated landscapes is essential.

2. Nature conditions

In the center of Taklamakan Desert, annual mean sunshine is 2500-2750 hours and annual mean air temperature is 11.5°C. Extremely high and low temperatures are 43.5°C (July) and -24.0°C (January) respectively. The ground maximum temperature is above 70°C. The active accumulated temperature is 4621.8°C. Yearly frost-free period is about 215 days. Annual precipitation is about 50mm. Annual evaporation is over 3000mm, which is 70 times the amount of former. Annual mean relative humidity is about 44%. Annual mean wind velocity can be 2.6m/s and 21.78m/s in maximum. The general wind direction is NEE.

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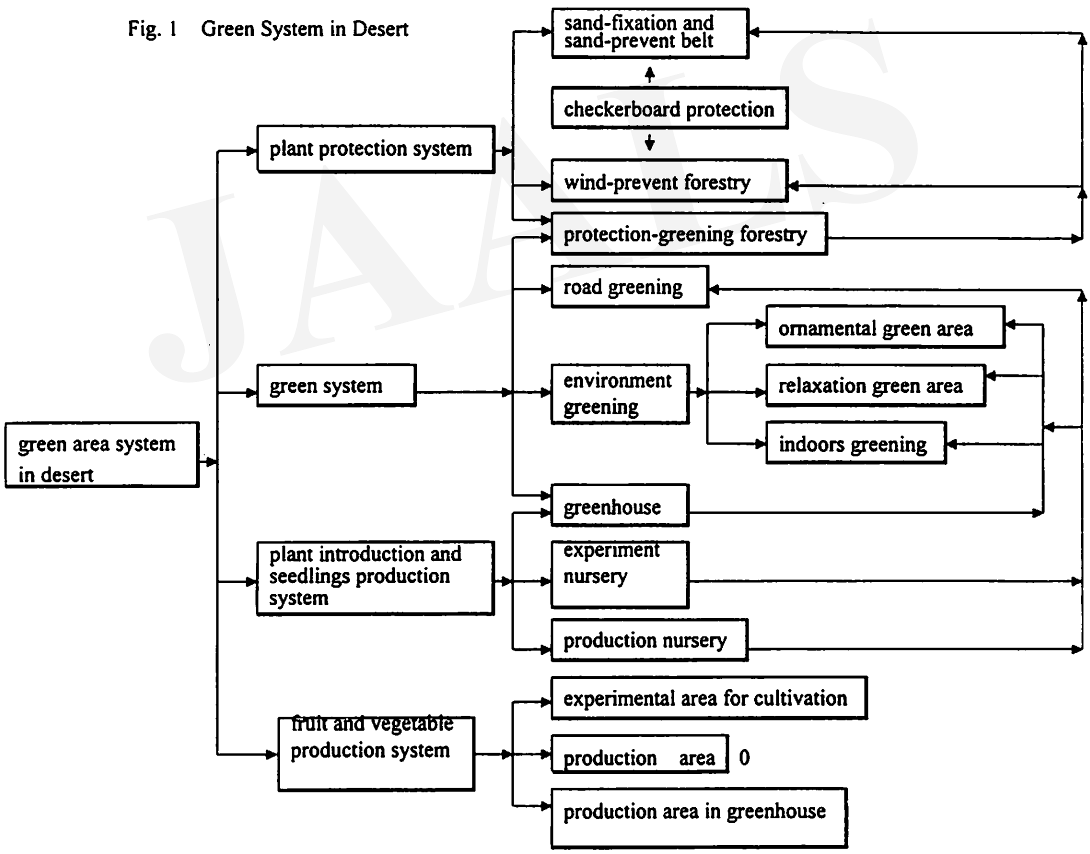
The dune sand grain size in Taklamakan Desert is 0.121mm, 45% of which are extremely fine sand, while silt content is 10%. The mean underlying sand size is 0.093mm, in which silt content is 27.4 %. SiO_2 content is 60%-70% in dune sand and underlying sand, followed by Al_2O_3, K_2O and Na_2O. Organic matter content is less than 1g/kg. Lime content is 115-121g/kg. Gypsum content is 2.5-4.3 g/kg. The total amounts of easy-dissolved salt is usually about 0.1 per cent (Zhou , 1996). Aeolian soil content is 1.5g/cm^2. Its specific gravity is 2.6-2.7g/cm^2. The porosity is about 43%. Ground water level is about 10m. Mineral content is about 4.23g/L, and the content of is Na^+ , CL^- and SO_4^{2-} are 1.11g/L, 1.74g/L and 1.06g/L, respectively.

3 Green area system in desert

Green area system as used in China refer to the landscape parks, lawns, and shade tree areas of a city. Through scientific classification, properly designed landscaping can greatly benefit human enjoyment of the environment. Land area is not a restraint for landscaping with green plants in desert, but the harsh conditions of the desert environment limit plant growth. Green plants ameliorate the harsh environment of desert. The green area system for oil field environments includes environmental landscaping, testing of plant material and propagation systems, and fruit and vegetable production systems (Fig. 1).

Fig. 1 Green System in Desert



A green area system might contain: a sand-fixation forestry plantation, shelter belt planting, green belt planting for road protection, landscape planting for residential and production areas, greenhouse and experimental nursery facilities, plus fruit and vegetable experimental production areas.

4. Tropics of research work

4.1 Monitoring of the environmental factors of oil field base in desert center. Mainly focus on climate , sand and wind , water and soil , organism and so on .

4.2 Selection experiment for resistant plant species
Including sand-fixation plant , fruit and vegetables , lawn and flowers .

4.3 Protective system of sand-defense and plantations

4.4 Irrigation technique of high mineral content water

4.5 Experiment at greenhouse for vegetable production

4.6 Outdoor lawn experiments

4.7 Outdoor culture experiment with vegetable production

4.8 Application of new technique and material
Including utilization of solar energy, application of water-saving pharmaceutical, sand fixation by salt water, soilless culture and application of modern fertilizer.

5 . The Results

5.1. As a result of 2 years of research (from 1994 to 1996) in the Taklamakan Desert , we have already established an monitoring system for environmental factors in the desert, including one autonomous meteological observation station and 2 climate observation sites in green area. We have gained basic data of the nature of conditions in the central desert by monitoring the followings: the movement of wind and sand, saltwater development, irrigated sand and its nature, the conditions of nutrition, water and salt content, the effects on human beings caused by animals and plants.

5.2. The construction of green area system in desert center had been carried out successfully. Two simple plastic green houses had been built with construction area of 421m^2 and planting area of 255m^2 and a green area had also been established with an area of 2.5 ha.

5.3. Currently, 165 species of plants have been introduced. More than 20 species of fruit tree and vegetables and 40 species of sand-fixation and greening plants have been cultivated successfully through different irrigation patterns , contain 4-5g/L of soluble salts.(table 1.)

Table 1. Planting conditions of green area system experiment

Content	Area of experiment	Kinds of experiment	Species numbers (experiment)	Species numbers (initially succeeded in planting)	Irrigation patterns
Cultivated in green house	$255m^2$	vegetables	22	20	border method of irrigation , drop irrigation
Cultivated in outdoors	$600m^2$	fruit and vegetables	21	19	border method of irrigation furrow irrigation
Sand-fixation plant	1.4 ha	introduction , domestication of plant	48	10	border method of irrigation furrow irrigation flood irrigation sprinkling irrigation
Nursery	0.14 ha	raise seedlings	10	10	border method of irrigation
Lawn	0.2 ha	introduction of plant, experimental construction	24	4	border method of irrigation
Flowers	3.3 ha	introduction of plant	27	4	border method of irrigation ,sprinkling irrigation
Fruit trees		introduction of plant	8	5	border method of irrigation

5.4 Forest production has been tentatively established in the desert by the transplanting of 300,000 saplings. These plantings provide the basis for further research on green land systems in the desert.

This manuscript reports on a very interesting research conducted on a truly massive scale in harsh desert condition. The authors have had difficulties with English, but if the correct English and style problems the paper should be published.

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