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POSTER ABSTRACTS

Comparison of Soil Compaction Under Conventional Agriculture and Conservation Agriculture Practices

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Background

This study took place at the National Institute for Field Crops in Tunisia, under the Project:" to Support Development of Conservation Agriculture" (a project funded by the French Agency for Development). In this study we tried to assess soil compaction under No-Till system. Two stations were selected to conduct this study, the first belongs to the INGC and it is at Bousalem, the second (a farmer site) in Krib. In these two stations eleven different fields conducted under different No-Ttill rotations and four fields under conventional system have been chosen to be subject of our experiments. Measurements of soil profiles have been taken.

Results

The results showed that there is no soil compaction at No-Till fields in all soil layers except where there has not been a soil decompaction before conversion to No-Ttill system. A soil compaction is widespread in the depths of 20 cm in soils conducted under conventional tillage due to the presence of a hardpan.

Applications and Implications for Conservation Agriculture

No tillage system does no induce soil compaction. Fields conducted under no tillage don't have compaction in all depths regardless of years under no tillage practice except fields where no decompacting achieved before converting to no tillage.

Soil compaction is widespread in soils conducted under conventional tillage at horizons located at 20 cm deep.

It is imperative to go through a diagnosis of the soil structural before the transition to no tillage**.**

Experimental Approach

The field work was conducted at two sites; the first belongs to the INGC, where we 8 fields, 2 under conventional tillage and 6 under no-tillage were chosen to establish assessments. For the second station, located in the Krib region, 7 fields were chosen, 2 under conventional tillage and 5 under no-tillage.

Table1: Characterization of fields under conventional tillage.

Field	site	Crop Rotation	Prvious Crop	water regime
SCa	Kodiat	Cereal/legumes	Small Faba bean	irrigated
SCb	Kodiat	Cereal/legumes	Small Faba bean	irrigated
SCcBD	Krib	Cereal/legumes	Small Faba bean	rainfed
SCcFev	Krib	Cereal/legumes	Durum Wheat	rainfed

Table 2: Characterization of fields under no tillage.

Field	site	Crop Rotation	Years Under No-Tillage	Previous Crop	water regime
SD1BD	Kodiat	Cereal/legumes	1	chickpea	irrigated
SD1Fen	Kodiat	Cereal/legumes	1	Durum Wheat	irrigated
SD2Fen	Kodiat	Cereal/legumes	2	Durum Wheat	irrigated
SD2Avo	Kodiat	Cereal/legumes	2	Small Faba bean	irrigated
SD6	Kodiat	Cereal/legumes	6	Small Faba bean	irrigated
SD8	Kodiat	Cereal/legumes	8	sorghum	irrigated
SD4	Krib	Cereal/legumes	4	Small Faba bean	rainfed
SD7	Krib	Cereal/legumes	7	Durum wheat	rainfed
SD10BD	Krib	Cereal/legumes	10	Small Faba bean	rainfed
SD10Fev	Krib	Cereal/legumes	10	Durum Wheat	rainfed
SD11	Krib	Cereal/legumes	11	Small Faba bean	rainfed

Assessments were about measurements of soil profiles.

Characterization of soil structure on a morphological basis was performed using two criteria. The first tests the size and the distribution of clods and how they are grouped (o, b, c). The second one is for the classification of these clods into three types (Δ, Γ, Φ), based on the importance and origin of their internal structural porosity (Roger et al, 2004). Soil profiles were installed in the following fields, Kodiat: SD1Fen, SD2Fen, SD6, SD8, SCa and SCb and Krib in fields: SD7, SD10BD, SD11 and SCcBD. Rules for soil profile diagnostic are listed in Table 4:

Table 3: Rules for soil profile diagnostic (Roger et *al*, 2004)

Structure	Degree of compaction
oΓ	Not compacted
cΓ	Begining of compaction
cΦ	moderate compaction
cΔ	severe compaction

Results and Discussion

Soil profiles in SD1, SD2 and SD8, have a structure that varies from oΓ to cΓ in all depths, soils are well aggregated, they are not compacted.

The soil profile of the field SD6 has a structure Γ in the surface layer (10 cm), the soil is not compacted in this layer, this structure is due to a strong biological activity and also to a high content of organic matter. In the 10-40 cm layer, the structure is cΦ, the soil has a moderate compaction.

The soil profile in both fields conducted under conventional tillage (SCa and SCb) shows good structure in the surface horizons 0-20 cm, these horizons are often prone to intensive tillage, and a compacted structure for SCa at the top 5 centimeters due to the effect of irrigation which generates a hardpan. As against, between 20 and 50 cm of the soil structure is moderately to highly compacted. This situation is due to the compaction effect of the plowing tools which create a hardpan.

Table 4: morphological structure of soil profiles in Krib station

Depth	SD7	SD10BD	SD11	SCCBD
0-5	oΓ	oΓ	oΓ	TF
5-10	cΓ	cΓ	cΓ	oΓ
10-20	cΓ	cΓ	cΓ	cΓ
20-30	cΓ	cΦ	cΓ	cΦ
30-40	cΓ	cΦ	cΓ	cΦ
40-50	cΓ	cΦ	cΓ	cΦ

Comparing the structure of the soil throughout the soil profile between conventional tillage and no tillage reveals a good structure in the 0-20 cm levels for both cropping systems. A difference is observed at 20-50 horizons where the structure becomes highly compacted in conventional tillage, except for the plot SD6 where there's no decompacting before moving to no tillage. This compacted structure under conventional tillage (cΦ to cΔ) is due to tillage causing a hardpan, the presence of taproots and a high biological activity confer soil under no tillage good structure.

In the SD7 and SD11 fields, soils have a good structure, the clods are aggregated and with good porosity throughout the soil profile, this structure is more porous than in fields SD1, SD2 and SD8 because the texture of the soil is predominantly sandy.

For both SD10 and SCc, compaction starts from 20 cm depth where the structure becomes more compacted and less porous (cΦ).

Table 5: morphological structure of soil profiles in koudiat station

Depth	SD1	SD2	SD6	SD8	SCa	SCb
0-5	oΓ	oΓ	oΓ	oΓ	cΓ	oΓ
5-10	oΓ	oΓ	cΓ	cΓ	cΓ	cΓ
10-20	oΓ	oΓ	cΦ	cΓ	cΓ	cΓ
20-30	oΓ	oΓ	cΦ	cΓ	cΓ	cΦ
30-40	oΓ	oΓ	cΦ	cΓ	cΔ	cΦ
40-50	oΓ	oΓ	TF	cΓ	cΔ	TF

Fields conducted under no tillage don't have compaction in all depths regardless of years under no tillage practice except fields where decompacting achieved before converting to no tillage. No tillage system does no induce soil compaction. Soil compaction is widespread in soils conducted under conventional tillage at horizons located at 20 cm deep. It is imperative to go through a diagnosis of the soil structural before the transition to no tillage**.**

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A Farmer-Centered Innovation Systems Approach to Stimulate Adoption of Conservation Agriculture in South Africa

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Background
There is now increasing understanding that crop production research and development (R&D) to improve natural resource management (through CA) does not follow a linear process. An innovation systems (IS) perspective to R&D reveals that the actual change and innovation processes are much more complex and diverse.

The above-mentioned implies that it is unlikely that complex, multi-component technologies such as CA can be successfully scaled out (mainstreamed) through traditional linear models of R&D. Instead they require the development of IS to adapt technologies to local conditions. Accordingly, and at the very least, the emphasis has to be on various aspects of the system, of which on-farm research and the inescapable experiential and social learning that this generates are key elements; both of which *critically place the farmer in the central role.*

Approach
To address these concerns, a grain-producers organization (Grain SA), supported by two commodity trusts (i.e. the Maize and Winter Cereal Trusts) launched a CA-Farmer Innovation Programme (FIP) to mainstream CA by and through grain farmers to ensure sustainable use and management of natural resources while enhancing national and household food security and income in South Africa.

The CA-FIP is designed to provide direct, fairly simple support and/or competitive access to funds for key and interested stakeholders (including farmers) who wish to promote CA. The CA-FIP investment in CA innovation will mainly be through solicited and non-solicited projects. Access to such funding allows a wide range of innovations to be tackled, and under proper conditions may expand enthusiasm and innovation capacity among farmers, other rural stakeholders, and those who support them, ultimately facilitating the mainstreaming of CA within the grain industry.

The Key Strategic Objectives that have been implemented since the initiation of the CA-FIP in 2013 are: a) documentation of CA systems, b) awareness and on-farm research.

Results
To **document** successful CA systems in various regions of South Africa, a clear and 'pure' description of a range of CA farming systems successfully practiced by farmers in specific areas are continuously done. This information will form the basis of a 'living manual' for farmers interested to start CA in any specific area. These descriptions have been published in popular agricultural magazines and will be available from the Grain SA website.

General **awareness** (or sensitisation) has been viewed as particularly important in stimulating farmers to get involved with further learning activities, such as experimentation. The argument is that the whole CA farmer innovation process usually needs an 'impulse' or an injection of energy (knowledge) to start or to speed-up the momentum and mostly it is a specific awareness event that achieves that. In this period a number of CA information days have been launched and supported, such as farmers days, conferences, posters and presentations at farmer groups. A first ever CA two-day conference was held in the North West Province, which is characterize by dry and sandy soil conditions, traditionally not seen as suitable for the application of CA practices.

Two new **IS Research projects** have been initiated in different study areas under the banner of the CA-FIP at Grain SA. In the North West Province, a project investigates commercial CA practices under semi-arid, sandy soil conditions, while the focus in the KwaZulu-Natal and Eastern Cape project is on challenges facing small holder farmers in the adoption of CA. These CA-FIP projects advocate the CA-FIP's new strategy on CA and strictly follows an on-farm, farmer-led approach, whereby farmers conduct their own experiments, which are properly designed and well supported by researchers, input suppliers and manufacturers. The prime objectives of these projects are to empower farmers and to construct and scale out appropriate CA systems to as many other interested farmers as possible. After one season the progress and results of these projects have been remarkable, illustrating a very positive response by farmers as far as ownership and innovation are concerned.

A further four official **demonstration trials** in various agro-ecological regions of South Africa have formed the basis of a cooperation agreement between Grain SA and Argentina, which aims to demonstrate the Argentinian CA technology to South African farmers. Results from the 2012/13 growing season have shown significant yield increases in most CA treatments compared to conventional systems. Three official sites have been identified to continue, while technical and institutional protocols have been redefined.

The CA-FIP has viewed constructive participation in various **innovation platforms**, such as the National CA Task Force (NCATF), as a strategy of national importance. The purpose of these forums is to advance the promotion of CA in South Africa through facilitating vigorous dialogue among various interested and key stakeholders in CA. A number of meetings were held to advance innovation platforms on various levels, especially on farmer level. Grain SA believes that the best way for disseminating the results of the on-farm CA research is through the likes of individuals within a famer study group, or a particular study group interacting with other study groups, through large farmer information days, through community structures, and through multi-stakeholder innovation platforms.

Discussion and Conclusion

After one year of implementing the CA-FIP, initial results show the multiple benefits of encouraging and supporting farmers to be active participants in adopting, and innovating for, CA. The IS approach builds a bridge between science and farmers, which leads to a range of social, economic and environmental benefits. This approach is vital to create a paradigm shift among the many SA farmers who have not yet moved towards CA in their farming systems.

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Design and Agronomic Assessment of an Implement for Conservation Agriculture Bed Planting in Tunisia.

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Worldwide water is becoming a scarse resource particularly in semiarid areas. Prediction scenarios show it will be increasingly so in the coming. This will limit crop production and jeopardize human livelihood. Moreover, volatile energy prices will impose significant changes in farmer practices because of the economic implications on farming net returns. Traditional irrigated cropping systems in Tunisia use intensive soil tillage and flood (flat) irrigation techniques, which generally lead to a water table depletion, soil compaction, poor water use efficiency and low crop productivity. Previous studies in other countries (Mexico, Bangladesh...), indicate significant advantages with conservation agriculture (CA) and raised bed techniques. These were not assessed before in Tunisia. A three year work conducted during 2010-2013 period at Chbika experimental Station in central Tunisia (35°37'13.71''N, 9°56'16.23''E) showed a potential for net benefits from a combination of CA and irrigation using raised beds techniques. During the first year grain yield of two durum varieties were collected from fresh raised 60 cm width beds and flat irrigated 200 m² plots with two replications. During the second year, the same varieties were sown on fresh bed, permanent bed and flat irrigated plots that harbored a faba bean crop during the previous year. In the third year both varieties were sown on same first year (permanent bed, fresh and flat) plots that were sown to faba bean during the second year.

Seeding was done during the first week of december during the three years. Seeding rates were 180 kg/ha and 150 Kg/ha respectively for Maali and Khiar on raised beds and 220 Kg/ ha and 180 Kg/ha for the same varieties on flat irrigated plots.

Fig: an implement was built to create beds and an old conventional seeder was used with low disturbance points, modified wheel placement and row spacing to fit the beds

Preliminary results show that sowing on raised beds resulted in a 0.2 to 0.3 t/ha yield increase in both varieties and during the three cropping seasons compared to flat irrigation. However, differences were not significant. Moreover sowing on raised beds used 20% less seeds compared to flat irrigated plots. This will add to economic benefit of sowing on raised beds. This technique helped also reduce time for soil preparation by 4.75 to 5.75 h/ha, which represent around 20% of total production cost. Irrigation with raised beds used 20 to 30 % less water than flat irrigation adding to the above-mentioned benefits. An implement was built to create beds. Wheel placement and row spacing were modified on an old conventional seeder with low disturbance points for seeding in the first year. In subsequent year, a new direct seeder with bed shaping parts was manufactured locally and used to seed CA plots. Nearby farmers were impressed with the initial results during field days and some are keen to test this technology.

Keywords: raised bed, irrigation, zero tillage seeder, reduced tillage

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Conservation Agriculture Practices for the Sustainability of Wheat Productivity and Profitability

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Intensive tillage, especially wet tillage for growing rice, in the rice-wheat cropping system of the North Western Indo-Gangetic plains has led to the deterioration of soil as well as depletion of groundwater resources (Nayar and Gill 1994). The condition is further worsened by burning of crop residues leading to loss of important organic source and micro-flora as well as causing environmental pollution. Therefore, depleting soil organic carbon, decreasing soil fertility and reduced factor productivity are the issues of concern (Yadav 1998). If we continue to exploit the natural resources at the current level, productivity and sustainability are bound to suffer. Efficient and environmental friendly management of crop residues is a must to reverse the degradation of natural resources. Therefore, to achieve sustainable higher productivity, efforts must be focussed on reversing the natural resource degradation by adopting conservation agriculture practices.

Long term field experiments (9 years) are in progress at the research farm of the Directorate of Wheat Research, Karnal, Haryana, India, to evaluate the effect of direct drilling of wheat into rice crop residues on nutrient and water use, soil properties and productivity of wheat in rice-wheat-green gram cropping system. Rotary disc drill-a machine developed at the Directorate of Wheat Research is being used for seeding wheat, rice and green gram crops into loose residues. Retention or incorporation of rice, wheat or both crop residues along with green gram increased soil organic carbon (OC) to more than 0.50 percent from the initial contents of 0.32 percent in the top 15-cm soil layer. In residue removal treatments also there was some increase in soil OC but in case of residue burning there was no change in soil OC which rather showed marginal decline. The other benefits of residue retention were decreased soil strength and lower weed infestation. The soil bulk density in the top 15 cm soil layer was lowest in residue incorporation and highest in residue burning treatments. The effect of residue management options, nitrogen and their interaction effects were significant on wheat productivity (Table 1). Residue removal, retention and burning treatments gave higher yields compared to the crop residue incorporation treatments. The lower yield levels in residue incorporation treatment might be due temporary immobilisation of soil nitrogen leading to decreased availability to the growing crop.

Table 1. Residue management options and nitrogen levels in wheat productivity

Residue Management Options	Nitrogen Levels, kg/ha			Means
	100	**150**	**200**	
Removal of both rice and wheat	41.64	50.12	51.99	**47.91**
Incorporation of both rice and wheat	39.50	47.36	50.65	**45.84**
Incorporation of rice	40.02	46.53	49.62	**45.39**
Burning of both rice and wheat	42.18	49.72	51.95	**47.95**
Burning of rice	43.11	49.85	53.00	**48.65**
Retention of both rice and wheat	41.95	49.20	49.53	**46.89**
Retention of rice	43.07	48.97	51.11	**47.72**
Mean	**41.64**	**48.82**	**51.12**	

LSD (0.05)	Residue Management Options (A)	Nitrogen Levels (B)	B within	A within B
	0.91	0.56	1.48	1.51

To evaluate the effect of conservation agriculture practices on water requirement for wheat, the experiment with five irrigation schedules of 2 to 6 irrigations based on critical growth stages in main plots and four surface retained residue loads of 0 to 6 t/ha in subplots and replicated thrice was conducted. The surface retained residue and irrigation effects were significant. The yield was higher in surface retained residues of 6 t/ha compared to residue removal as well as surface residue of 2 t/ha (Table 2). The surface retained residues also improved water use efficiency. Earlier *Sharma et al., 2005* reported water saving of about 2.58 per cent in zero tillage without surface residue retention compared to conventional and about 20 per cent in furrow irrigated bed planting system of wheat cultivation with similar yield levels. The yield of direct seeded rice was lower compared to puddle transplanted and that of green gram was equal or higher depending upon the prevailing climate during the crop growing period.

Table 2. Surface retained residue and irrigation effect on wheat productivity

Number of Irrigations		**Residue load, t/ha**				**Means**
		0	**2**	**4**	**6**	
2		45.07	45.73	46.54	47.43	46.19
3		46.36	47.16	47.59	48.37	47.37
4		47.68	48.38	49.00	48.50	48.39
5		48.23	48.21	49.25	49.61	48.82
6		49.71	50.17	50.50	50.97	50.33
Mean		47.41	47.93	48.58	48.98	
LSD (0.05)	Number of Irrigations (A)		Residue Load (B)		B within A	A within B
	0.88		0.65		NS	NS

The adoption of conservation agriculture practices helped increase soil OC, available NPK, infiltration rate, improved nutrient and water use efficiencies leading to higher productivity, profitability and sustainability of wheat in rice-wheat system. It has been reported that surface residue retention leads to slower decomposition compared to incorporation which helps build up soil organic carbon (*Havlin et al. 1990; Hooker et al. 1982; Unger 1991; Wood et al. 1990*). Moreover, leaving crop residues on the soil surface seems to be a better option than incorporation as it conserves soil moisture, suppresses weeds (*Chhokar et al. 2013*), avoids short-term nutrient tie up and reduces soil erosion.

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Conservation Agriculture-based Management Technologies for Improving Productivity and Profitability of Cotton-Wheat System in Northern-Western Indo-Gangetic Plains of South Asia

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Background

Cotton (*Gossypium hirsutum* L.) – wheat (*Triticum aestivum* L.) (CW) is the second most important cropping system after rice – wheat and covers ~ 4.02 mha acreage in South Asia. Long duration of cotton cultivars coupled with late pickings often delays wheat sowing. Late planting after 20th of November reduces wheat productivity by 1 – 1.5% per day (Nasrullah et al., 2010). This is mainly due to terminal heat stress encountered by wheat at the grain filling stage. With the changing climate scenario sustainability of CW production system has become a major issue for resource poor farmers in South Asia. Improvement in wheat productivity in CW system could help replace water guzzling rice in rice- wheat system Conservation agriculture based management practices have potential to produce more at less cost, reduce environmental pollution, improve soil health and promote timely planting of crops. Early sowing of wheat after cotton without disturbing the cotton crop is possible only by relay cropping of wheat (Buttar et al., 2013). Five on-farm trials were conducted to assess the effect of tillage and crop establishment techniques, and relay sown wheat on productivity and profitability of CW cropping system in south-western region of Punjab, India.

Experimental Approach

Replicated on – farm trials were laid out with three treatments at five locations during 2011–12 and 2012– 13 in Punjab, India. The climate of the region is subtropical, semi-arid and received about 460 mm of rainfall during the cotton season (April–November) and 75 mm during the wheat season (November– April).The soils were loamy sand to sandy loam in texture with pH ranging from 8.2 to 8.6 (soil–water ratio is 1:2) and organic carbon content varied from to 2.8 to 3.2 g kg^{-1} soil. The three treatments included in the study are: T1: Zero till cotton (ZTC) – Relay seeding of wheat in the standing cotton crop after the third picking, using the self-propelled relay-seeder without prior tillage (RZTSPS). T2: Conventional till cotton (CTC) – RZTSPS. T3: CTC – Conventional till wheat (CTW). Two-wheel tractor-based self- propelled relay seeder' with seed-cum-fertilizer attachment (Fig.1) was used to plant wheat in standing cotton. For statistical analysis, locations were considered as replications and the data for each year were subjected to analysis of variance in a randomized complete block design. The differences between two treatment means were considered significant only when $p \leq 0.05$.

Results and discussion

Seed cotton yield and wheat yield was significantly influenced by different planting methods during the years ($p \leq 0.05$, Table 1). The seed cotton yield was similar in ZTC – RZTSPS and CTC – RZTSPS treatments, but remained statistically superior to CTC – CTW. On an average, RZTSPS followed by ZTC or CTC recorded 9.25 and 9.06% higher seed cotton yield in 2012 and 2013, respectively compared to CTC – CTW. This was mainly due to additional picking of seed cotton in relay planted zero till wheat crop (Buttar et al., 2013). A similar trend was found in wheat yield and the system productivity. Mean grain yield of wheat sown with the relay seeder in ZTC – RZTSPS and CTC – RZTSPS was 18.5 and 33.6 % higher over CTW in 2011-12 and 2012-13, respectively. In this region, optimum time of wheat sowing is from fourth week of October to second week of November (Bajwa, 2011). The increase in wheat yield under relay seeding of wheat was primarily due to timely sowing of wheat. System productivity ranged from 12.26 to 14.38 t/ha in both years. CTC – CTW gave lowest system productivity (12.41 t/ha) as compared to ZTC– ZTSPS (14.21

t/ha) and CTC – RZTSPS (14.33 t/ha), irrespective of years. The net return was higher with ZTC/CTC – RZTSPS than CTC – CTW system. RZTSPS followed either by ZTC or CTC gave 20,365 and 29,475 Rs/ha higher net returns in 2011 and 2012, respectively over CTC – CTW. Further, among RZTSPS, ZTC gave 4,430 and 3,850 Rs/ha higher net returns over CTC during 2011 and 2012, respectively. This could be ascribed to higher yield with low cost of cultivation. On the basis of two years investigation we conclude that zero till cotton followed by l relay seeded wheat was the most productive and profitable system and could be an alternative option to raise yield potential of CW system in South Asia.

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Figures and Tables
Table 1. Effect of different planting methods on productivity and profitability of cotton-wheat system

Treatment	Seed cotton yield (t/ha)		Wheat yield (t/ha)		System productivity on wheat equivalent yield (t/ha)		Net returns (10^3 INR/ha)	
	2011	2012	2011-12	2012-13	2011	2012	2011	2012
ZTC – RZTSPS	2.87[a]	2.99[a]	6.05[a]	5.19[a]	14.15[a]	14.27[a]	128.94[a]	145.32[a]
CTC – RZTSPS	2.92[a]	3.03[a]	5.99[a]	5.18[a]	14.23[a]	14.38[a]	124.51[a]	141.47[a]
CTC – CTW	2.65[b]	2.76[b]	5.08[b]	3.88[b]	12.56[b]	12.26[b]	106.36[b]	113.92[b]

ZTC: Zero till cotton; RZTSPS: Relay seeding of wheat in standing cotton after 3rd picking, using self propelled relay seeder without prior tillage; CTC: Conventional till cotton; CTW: Conventional till wheat. Within a column, means followed by the same superscript letters are not significantly different at $p \leq 0.05$ by the Duncan's multiple range test.

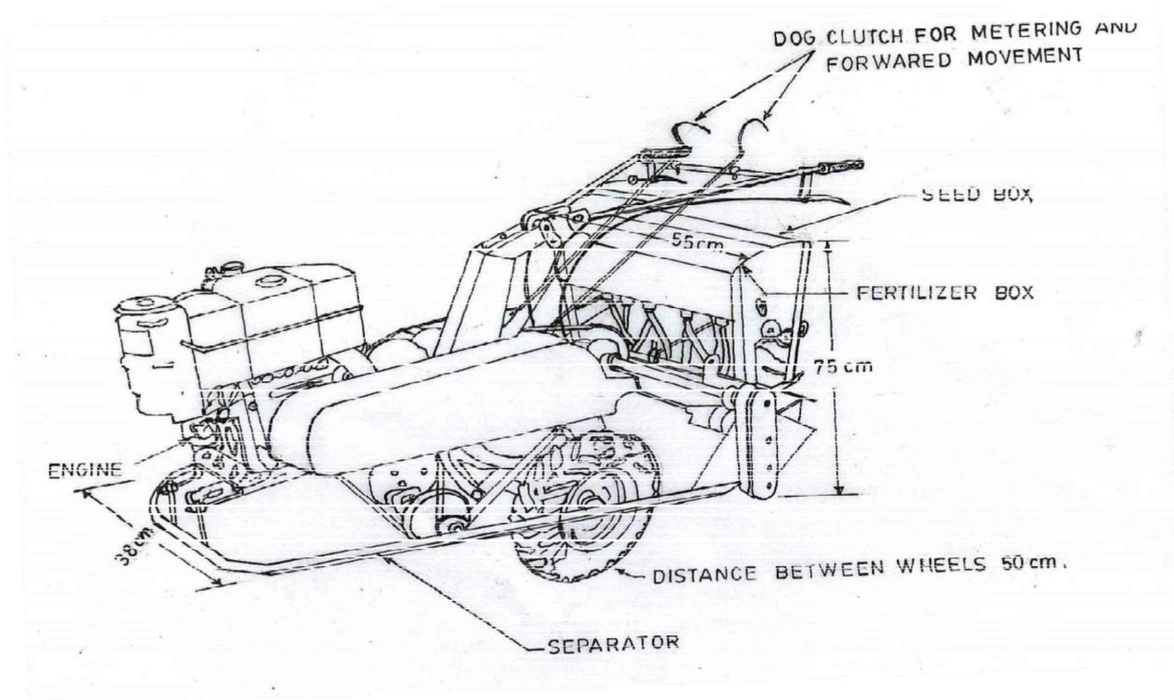

Fig.1 Self-propelled relay seeder for wheat sowing in two rows (67.5 cm width) of standing cotton

Sustainable Groundwater Management and Conservation Agriculture in Rajasthan, India

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Background

The economic growth of Rajasthan state (India) is largely dependent on water, more specifically on groundwater. It is estimated that 71% of the irrigation and 90% of the drinking water supply source is groundwater (Rathore, 2003). The groundwater pumping for irrigation purpose has increased more than three times in the last two and a half decade (from 1984 to 2009), the stage of ground water development in Rajasthan state is 125 (CGWB, 2009), which implies that in this state the average annual ground water consumption is more than average annual ground water availability (critical value 100). The worsening water balance in the state has resulted in the ever increasing numbers of blocks under the categories of over-exploited. The percentage of total number blocks under over-exploited category was 36% in 1984 but now it has increased to 70%. A range of on- ground works to recharge groundwater are being implemented at village scale throughout India as a part of the Government of India’s ‘M. National Rural Employment Guarantee Act’ (MNREGA). But there is no quantification of amount of recharge through the existing structures. For the safeguarding of groundwater and make it available for future, the use of management practices in conjunction with conservation agriculture have become essential for Rajasthan. One of the objectives of the project sponsored by ACIAR, titled ‘Managed Aquifer Recharge through Village Level Intervention (MARVI)’ is to improve the availability of groundwater for irrigation is under operation since last two years.

The Study Area

The Bhinder Block is situated in Udaipur district of Southern Rajasthan, India has been identified as ‘dark zone’ from the point of view of groundwater over-exploitation. For the last two years, the MARVI project is focussing on to quantify the extent of groundwater overexploitation in the Bhinder Block. The project site is in the Dharta Watershed in the Block, and it lies between 24° 30’ to 24° 37’ N latitude to 73° 05’ to 73° 15’E longitude. Five villages have been selected for a detailed study of groundwater fluctuation, socio-economic analysis and community engagement. The soil type in the watershed varies but tends to be mainly sandy loam. Topography is often undulating with slope up to 2.7%. The ground elevation of the area is 465m above the mean sea level. The average annual rainfall of Dharta is 607 mm. The long-term climatic data suggest that temperature in the watershed ranges from 19°C to 48°C in summer and 3.2°C to 28.9°C during winter season. The major crops grown in the area are maize, cluster bean (guar), chick pea, wheat, barley and mustard. About 25% of the total land area in the watershed is irrigated mainly by open wells and tubewells.

Methodology

For the estimation of water resource situation and the impact of groundwater availability, some baseline data of the study area were collected, particularly to understand future options for management and conservation practices in the watershed. A detailed monitoring framework was developed and implemented at the watershed.

The groundwater level in a total of 250 open wells was monitored with the help of local community members. Fifty wells were selected each of the five study villages of the watershed. The water level was recorded every week (Sundays). Five wells were also equipped with groundwater sensors for continuous monitoring (every 15 min) water table. A number of parameters of soil and water quality (EC, pH, TDS and SAR) were monitored at six monthly interval, i.e., before and after the monsoon season.

For monitoring water stored behind the recharge structures, water depth were taken during the pre-monsoon and post-monsoon seasons to understand the extent of recharge. One automatic weather station and five semi- automatic tipping bucket type rain-gauges were installed in the watershed. All selected wells were located on GIS environment for better understanding of the distribution of wells, MAR structures and their position on the map. Crop demonstrations were laid down at farmer's fields to demonstrate conservation techniques and field days at site were organized to share experiences and insights about conservation practices.

Community engagement was an important aspect of this study. This is because the groundwater management is a community issue and can be effectively achieved by empowering the local community. To connect all age group with this important issue, the engagement comprises of school students (future users) and local people (present farmers and other consumers). Students have been connected to the project through various activities like photo-voice, workshops, drawing competition, group discussions and measurement of rainfall. Further, local farmers, called *Bhujal Jankars* (BJs, Groundwater Informants) were selected and trained for collection of groundwater data, mapping of geology and spreading knowledge among community.

Results & Discussion

In this study, the work is still in progress and an attempt has been made to prepare baseline information and develop complete package of practices for management of groundwater for prominent cropping systems (with conservation agriculture) at village level (localised), particularly in rainfed and dryland region of Rajasthan. These results are showing the work done for reaching the comprehensive objectives of the project with the following key results.

- The groundwater data have been collected for the last two years and the analysis of these data being done to develop management strategies and policy options.
- The water level monitoring by farmers improved the knowledge of current situation of groundwater among farmers. Now they are aware about how much quantity of water they are using for irrigation and the project is now increasing the sensitivity and awareness of ground water depletion and other conservation issues.
- The engagement of local community and schools has helped to collect local groundwater data and their partnership in the project. The scientific activities performed in the project have developed interest of community to know more about groundwater.
- Crop demonstration conducted in the watershed made realised farmers that yield of crop per unit of water can be increased by using proper conservation agriculture practices like minimum tillage, mulching, crop rotation, intercropping and micro irrigation.

Conclusions

- Participation of the community and local people is important in implementing strategies and bring change for sustainable ground water management.
- Groundwater management is complex phenomenon and requires long-term data and in- depth consultation with local farmers and government agencies.
- Strong local champions are important as groundwater management is an important community issue.
- Activities that promote conservation agriculture have an important role in sustainable groundwater management.

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