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The Punjab Preservation of Subsoil Water Act: A Regulatory Mechanism for Saving Groundwater

Bharat R Sharma[1], G. K. Ambili[1] and BS Sidhu[2]
[1]International Water Management Institute, New Delhi Office, NASC Complex, New Delhi
[2]Directorate of Agriculture, Government of Punjab, Chandigarh

Abstract : Groundwater resources, believed to have played an important role in Green Revolution induced agricultural productivity rise in India, is under serious threat due to overdraft. The unregulated exploitation of this limited resource had brought Indian Punjab into a state of acute water crisis. Homogenized cropping followed in the state, with water guzzling rice being the highly favoured crop in *kharif*, is the most to blame for this resource crisis. The plunging water levels in the state led the state Government to regulate groundwater use by several direct and indirect measures. *The Punjab Preservation of Sub-soil Water Act-2009* is such an effort to conserve groundwater resource by mandatory delay in the transplanting paddy beyond 10th June to escape periods of very high evapo-transpiration demands. The present paper investigates the potential of the act in bringing about anticipated *real water savings of groundwater.* It also looks at the impact of this regulatory framework on savings in agricultural electricity consumption in the state.

Keywords: Delayed transplanting; real water savings; groundwater overdraft; falling water table; water productivity.

INTRODUCTION

Punjab, the granary of India, meets food deficit of several other states and is the major contributor of rice to the central pool of national food reserves. Water scarcity issues in Punjab are likely to create serious threat to national food security. Agricultural production in the state is mainly dependent on groundwater irrigation, which has followed an increasing trend (Sidhu and Bhullar, 2005) since the 1970s. Canal irrigated area in Punjab has seen a decrease of 10.8% from 1970-'71 to 2002-'03, whereas tubewell irrigated area has increased by 81% during the same period. Out of the total irrigation demand of 36.56 BCM, about 51% is obtained from groundwater (Virk, undated). The status of groundwater resources in the state is currently showing restrictive uses as most of the districts are now under the *'over-exploited'* category. Excessive groundwater draft for agriculture has led to water tables dropping at an alarming rate in parts of the state. Around 90% of the area in Punjab is experiencing falling water tables. North-Western India including Punjab is experiencing groundwater level drop at an average rate of 4.0±1.0 cm/yr (Rodell et al., 2009). The situation in Central Punjab is more severe; the average fall in water table from 1993-2003 was around 50cm per annum (http://dswcpunjab.gov.in/contents/Laser_Leveling.htm).

Despite the grave situation caused by over-exploitation of groundwater, farmers grew water-intensive crops such as rice and sugarcane due to favourable energy and grain support price policies. Irrigation for rice has been identified as a major contributor of groundwater crisis experienced in the state (Jat et al., 2009). A survey conducted by National Sample Survey Organization (NSSO), India showed around 89% of 2003 *kharif* area in Punjab being irrigated by tubewells. Power sector policies promote excessive agricultural groundwater use. Subsidized free power for agriculture in Punjab reduced the marginal cost of pumping to zero, which led to farmers giving preference to groundwater over canal irrigation. Food policies also indirectly have a decisive influence on groundwater exploitation.

Procurement of rice for the central pool is more or less skewed towards the states of Punjab and Andhra Pradesh (Table 1). Additionally, the high minimum support price (MSP) offered for rice made it advantageous for farmers to opt for cultivating rice as the major *kharif* crop (Sinha et al., 2006). A substantial increase has been noticed in MSP (Table 2) over the last decade. The MSP fixed for 2008-09 showed an increase of around 30% from that of the previous year.

The general tendency among farmers in Punjab is to go for transplanting in the hot month of May after immediate harvest of wheat crop due to shortage of labor at later months. High temperatures in the month of May (around 45°

Table 1 : State-wise percentage contribution of rice to central pool

State	Percentage of quantity procured to total procurement				
	2003-04	2004-05	2005-06	2006-07	2007-08
Punjab	37.94	36.9	32.02	31.22	27.75
Andhra Pradesh	18.53	15.8	17.97	21.24	26.03
Chattisgarh		11.5	11.8	11.4	9.63
Uttar Pradesh	11.19	12	11.39	10.17	10.15
Orissa	6.01	6.4	6.45	7.95	8.21
Haryana	5.84	6.7	7.43	7.07	5.51
Others	20.49	10.7	12.92	10.95	12.72

Source: Department of Food and Public Distribution, Government of India

Table 2. Trend in Minimum Support Price (MSP) of rice

Crop year	MSP for rice (INR per quintal)		Percentage change	
	Common	Grade A	Common	Grade A
1997-98	415	455		
1998-99	440	470	6.02	3.30
1999-2000	490	520	11.36	10.64
2000-01	510	540	4.08	3.85
2001-02	530	560	3.92	3.70
2002-03	530[#]	560[#]	0.00	0.00
2003-04	550	580	3.77	3.57
2004-05	560	590	1.82	1.72
2005-06	570	600	1.79	1.69
2006-07	580[$]	610[$]	1.75	1.67
2007-08	645	675	11.21	10.66
2008-09	850[&]	880[&]	31.78	30.37

Source: Department of Agriculture and Cooperatives, Government of India

[#] One time special drought relief of INR 20 per quintal was given over and above MSP

[$] An additional incentive bonus of INR 40 per quintal was payable on procurement between 1.10.2006 to 31.03.2007

An additional incentive bonus of INR 100 per quintal was payable over MSP

[&] Bonus of INR 50 per quintal is payable over MSP

Celsius) necessitate more frequent irrigation, causing farmers to pump more water from the already depleted groundwater resources. Large crop water requirements for rice coupled with the high ET requirement in May (Table 3) induced by climatic conditions make the water situation even worse. Evaporation accounts for 60% of the actual total water depletion (ET) for rice during the crop growth period. And hence real water savings are possible only by reducing this non-beneficial water loss through rescheduling the transplanting dates (Ahmad *et al.*, 2007). Transplanting rice seedlings late in June would also serve as a coping strategy in case of delayed monsoons.

THE PUNJAB PRESERVATION OF SUB-SOIL WATERACT

Alarmed by the state-wide deteriorating groundwater situation and to work out effective solutions for groundwater over-pumping issues and consequent water table declines in Punjab, the state Government with recommendation from the research institutes and Punjab State Farmers Commission (Singh, 2006) , promulgated an Ordinance in 2008 followed by the act, "The Punjab Preservation of Subsoil Water Act" in March 2009. Through the main provisions of this Act, it has been made mandatory for all farmers not to sow paddy nursery before May 10 and not to go for transplanting before June 10. The Act also carries a stringent penalty clause for the defaulters (a fine of INR 10,000 per hectare of the transplanted field plus the cost of uprooting the crop). Previous advisories on water savings and even water saving practices have made little dent on groundwater depletion. Regulation on pumping from overexploited and critical areas had only limited impact. The overall stage of groundwater development in the state is 145%. Out of 137 blocks in the state, 103 have fallen under "over-exploited[1]" category. The move to diversify cropping pattern by extending MSP to crops other than paddy has not been received favourably by the farmers, as can be seen from the consistency in rice sown area over the years. However, all these measures have yielded little or no success in bringing down groundwater pumping to sustainable levels. This necessitated the promulgation of such an ordinance and the Act. In the present paper, we attempt to investigate whether the regulation by Punjab Government to alter the cropping calendar by delaying the date of transplanting would give the anticipated water savings.

The real water savings were analysed, in terms of ET, that could be achieved by shifting the transplanting dates from 01 May to 10 June. Crop ET requirements were calculated using CROPWAT, for two commonly cultivated varieties

Table 3 : District-wise monthly mean potential evapotranspiration rates (mm/day) in Punjab (1901-2000)

District	May	June	July	District	May	June	July
Amritsar	8.98	8.98	7.22	Ludhiana	9.06	8.83	7.09
Bathinda	9.04	8.82	7.25	Mansa	8.97	8.71	7.13
Faridkot	9.1	8.96	7.33	Moga	9.08	8.93	7.22
Fatehgarh Sahib	8.98	8.7	7	Muktsar	9.11	8.94	7.4
Firozpur	9.14	9	7.42	Nawanshahr	9.1	8.9	7.09
Gurdaspur	8.89	8.94	7.15	Patiala	8.9	8.58	6.94
Hoshiarpur	8.99	8.91	7.12	Rupnagar	9.02	8.77	7.02
Jalandhar	9.05	8.94	7.16	Sangrur	8.98	8.71	7.07
Kapurthala	9.03	8.97	7.18				

of rice; PR115, a medium duration variety (125 days) and PR113 , a long duration (142 Days) variety. The analysis provides conservative estimates of potential water savings, based on long-term average ET values (from 1901-2000). Results showedan increasing trend in water savings as farmers delay the transplanting date by 1-6 weeks (Figure 1 (a) and (b)). The increasing trend is noticeable in all districts of the state. The ET gains from 14 mm to 90 mm could be achieved for the long duration variety by a delay of 1 and 6 week respectively, whereas for medium duration PR115, the expected gains in the ET is close to 80 mm, by transplanting paddy after the recommended date of 10 June. Evapo-transpiration demand of the crop reduces by 1.8, 2.4, 3.5, 6.1, 8.6 and 9.3% through shifting of transplanting dates by 1 to 6 weeks.

The intervention, when integrated with other management options, brings additional savings in ET. Integrated effects of late transplanting and cultivar type can double the ET savings as opposed to single intervention of shifting the

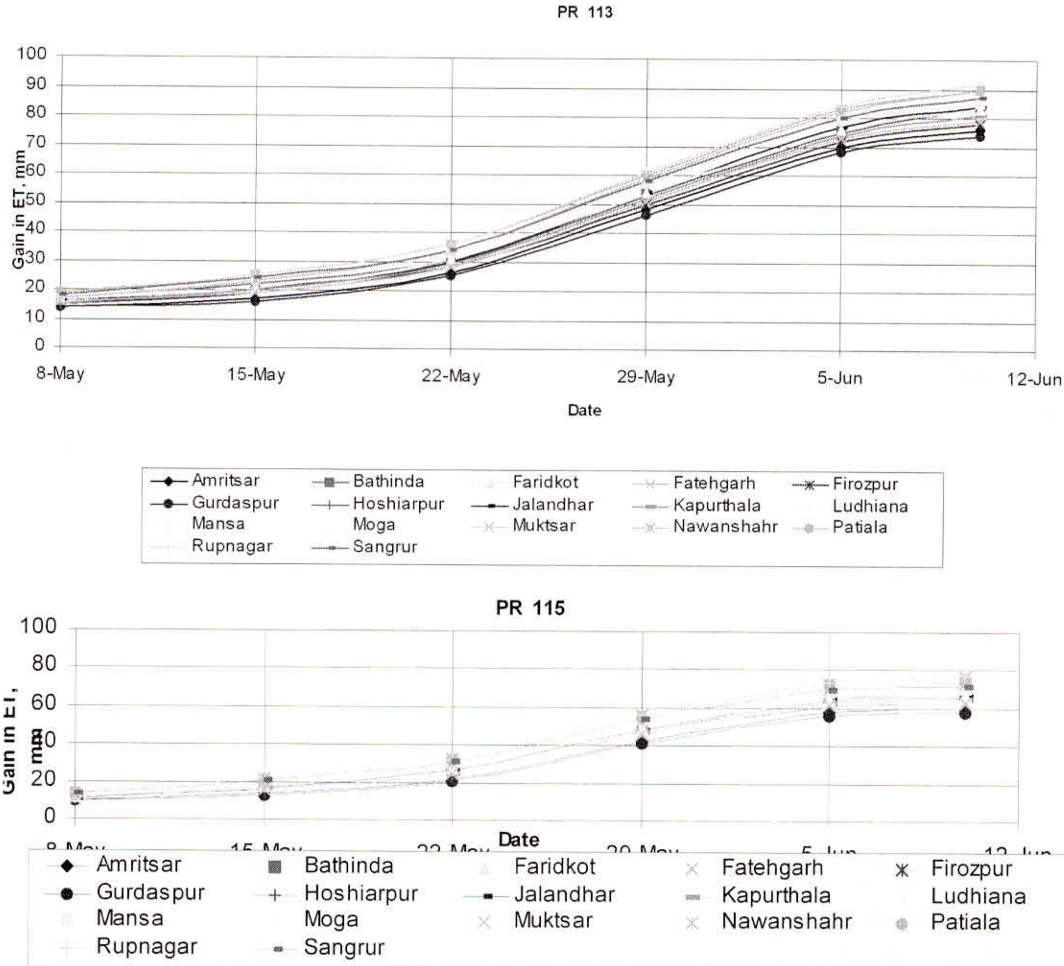

Fig. 1 : Evapotranspiration (ET) gains by delaying the transplanting date from May 1st to 10th June for PR113 and PR115 varieties of paddy.

transplanting date. Shifting of transplanting date (from 5 May to 25 June) along with growing short duration hybrid varieties having high harvest index can bring about real water savings of 140 mm, almost double than managing a single intervention; 66 mm by delaying transplanting date and 71 mm by using short duration hybrid variety (Jalota et al., 2009).

SPATIAL EXTRAPOLATION

With such simple water management option, the 'real' loss of water can be checked; and this ,in turn, can help save considerable amounts of water if adopted on a wider scale, as depicted in Figure 2. Since the savings at field level are the non-productive evaporation loss, the savings get aggregated at higher scales. If the whole rice cropped area (2.62 million ha) of Punjab follow late transplanting by 10th of June, water savings that could be achieved would be around 2,180 MCM and 1,770 MCM for PR 113 and PR115 varieties respectively (rice area of 2006-'07 taken as reference). Transplanting on10th of June would ensure a savings of 7% and 5% in annual GW draft for irrigation, as given in Table 4. Even a slight decrease in groundwater withdrawals would be of greater significance as most parts of the state is underlain by overexploited aquifers; some districts even with more than 200% groundwater development. Decrease in groundwater pumpage will eventually help in rising groundwater levels. Studies suggested that decrease in water requirement by 26 to 30 cms, effected by the Act would check the water table decline by 60 to 65% (Singh, 2009). Rise in water table upto two to three meters has been reported from northern districts of Punjab, attributable to the act (The Tribune, Chandigarh, 4 June 2009).

IMPROVEMENT IN WATER PRODUCTIVITY

An important concern of farmers with delayed transplanting is whether it affects the yield of the crop. Farmers may not be willing to voluntarily adopt this strategy unless it is assured that they get similar or higher yields with the use of smaller quantities of water. Studies showed that mean grain yields were higher for 15 June, but were reduced when the transplanting dates were delayed further to 5 July (Mahajan et al., 2009). Research by ICAR Research Complex for Eastern

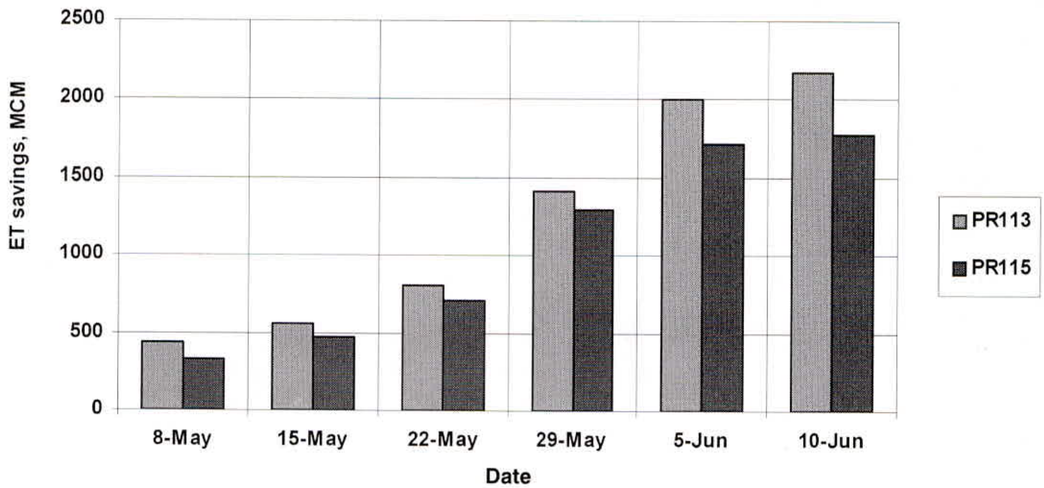

Fig. 2 : Real savings in water by delayed transplanting over total rice area in Punjab

Table 4 : Potential savings in groundwater use by shifting the transplanting date to 10th June.

District	Annual GW draft for irrigation ha-m*	Percentage savings (%)		Stage of GW development (%)
		PR 113	PR 115	
Amritsar	366699	7.27	5.74	152
Bathinda	78412	9.21	7.43	93
Faridkot	54056	12.74	10.06	106
Fatehgarh	83552	9.05	7.64	161
Firozpur	228769	8.01	6.47	105
Gurdaspur	193600	7.68	6.02	107
Hoshiarpur	74603	6.23	4.95	85
Jalandhar	257084	4.80	3.83	254
Kapurthala	124929	7.13	5.72	204
Ludhiana	323274	6.83	5.68	144
Mansa	140412	3.75	3.14	175
Moga	214540	6.50	5.25	178
Muktsar	51990	10.33	8.24	62
Nawanshahr	114933	4.15	3.41	175
Patiala	264951	8.05	6.71	165
Rupnagar	47717	12.92	10.81	93
Sangrur	414055	7.61	6.29	183
State	3033576	7.18	5.84	145

*CGWB (2006)

Region has shown that optimum dates for transplanting of rice is between last week of June to mid July, which would give an average yield of about 6.6 t/ha, by maximum utilization of rainwater. Transplanting in August would result in a loss of 2-3 irrigations. Contrary to this, simulations by Arora (2006) showed a slight reduction in mean grain yields for late transplanted rice. Optimum air temperatures at 15 June increased number of tillers/m^2, causing the yields to improve. For late transplanted rice, the frequency of number of days with temperature higher than the upper limit of optimum temperatures (37^{0}C) remains shorter. High temperature and other weather parameters of each such day would reduce the rice yield by 37 kg. All the above mentioned studies indicated rice yields obtained by shifting the transplanting dates to be higher than the state average of 5.5 t/ha (Chahal et al., 2007)

Higher yields contributed by favourable temperature and other weather parameters cause the water productivity to rise even when irrigation water applied was more for rice transplanted as late as during the first week of July. Similar effects were noticed for total water productivity as well. Simulation studies indicated increases in mean water productivity by around 10% and 21% for paddy transplanted on June 1 and June 16 respectively, as compared to that of May 16 (Arora, 2006). Late transplanting of paddy might also affect the sowing date of wheat. Growing early maturing varieties of paddy could solve this problem to a greater extent.

IMPACT ON AGRICULTURAL ENERGY CONSUMPTION

The complementary linkage between water and energy suggests that this savings in ET is decidedly going to have positive impacts on energy for groundwater pumping. Around 31% of the electricity consumption in the state is for agriculture, but have only a small, barely negligible contribution to revenue generation. With falling water tables, electrical energy requirement to pump groundwater from greater depths is on the rise. This underscores the need to know the magnitude of savings in agricultural energy consumption possible if the real water savings (as estimated in section 3) are assigned to reduced groundwater extraction for irrigation. Assuming that one irrigation applies 7 cm of water, transplanting by 10th of June saves on an average 1 irrigation. This takes into account only the ET requirements, and not the total water application for the crop. By assuming that it takes 10 hrs to irrigate 1 ha, total hours saved for electricity for the whole state is around 31 million and 25 million for PR113 and PR115 varieties respectively (Table 5). It is estimated that farmers growing long duration rice could save approximately 175 million KWh of electricity by checking real water loss ;and for the

Table 5 : Potential savings in electricity by shifting transplanting date to 10th June

District	No. of hrs saved per ha		Total pump hrs saved (million hrs)		Total electricity savings (million KWh)#	
	PR 113	PR 115	PR 113	PR 115	PR 113	PR 115
Amritsar	10.86	8.57	3.81	3.01	21.44	16.92
Bathinda	11.86	9.57	1.03	0.83	5.80	4.68
Faridkot	11.57	9.14	0.98	0.78	5.53	4.37
Fatehgarh	12.86	10.86	1.08	0.91	6.08	5.13
Firozpur	11.14	9.00	2.62	2.12	14.73	11.90
Gurdaspur	10.57	8.29	2.12	1.67	11.95	9.37
Hoshiarpur	11.86	9.43	0.66	0.53	3.74	2.97
Jalandhar	12.00	9.57	1.76	1.41	9.92	7.91
Kapurthala	11.57	9.29	1.27	1.02	7.16	5.75
Ludhiana	12.71	10.57	3.15	2.62	17.74	14.75
Mansa	12.14	10.14	0.75	0.63	4.23	3.54
Moga	11.86	9.57	1.99	1.61	11.21	9.05
Muktsar	11.29	9.00	0.77	0.61	4.32	3.44
Nawanshahr	12.86	10.57	0.68	0.56	3.83	3.15
Patiala	12.86	10.71	3.05	2.54	17.14	14.28
Rupnagar	13.14	11.00	0.88	0.74	4.95	4.15
Sangrur	12.43	10.29	4.50	3.72	25.31	20.94
State Total			31.12	25.30	175.07	142.30

#For a pump capacity of 7.5 hp

medium duration variety corresponding electricity savings would be approximately 142 million KWh. This would mean an average of around 2% savings in total agricultural electricity consumption (8229.49 million KWh). Poor and marginal farmers are likely to have relatively more economic benefits by this savings in electricity, as they spend a higher proportion of their household income on purchase/renting of pumps. Greater electricity savings are possible in districts with more number of energized tubewells such as in Sangrur, Amritsar, Ludhiana and Patiala. Actual electricity savings of 276 million units for agriculture reported by Punjab State Electricity Board in 2008-09 paddy season has also been attributed to the impact of the Act (The Tribune, Chandigarh, 5 June 2009); that too in spite of an increase in rice area by 1.53% and increase in tubewell connections by 3.7% (Singh, 2009). The energy savings are translated to cost savings for the State Electricity Board, which has been burdened with added cost on account of subsidies on agricultural pumping[2]. The role played by pressure politics on subsidies is substantial and any move to eliminate subsidies would be fraught with strong opposition. Hence, such an indirect measure to conserve energy use in agriculture is a probable way to bring savings to the state exchequer.

EFFECTIVENESS OF THE ACT

Although it is still early to evaluate the impacts of such an act, there are prima facie reports citing effective implementation. The initial adoption rate has been high, with only 0.6% of farmers transplanting upto end of May in 2008, when the act was introduced as an ordinance (Singh, 2009). Delayed transplanting offers a very promising solution to revert back the water table decline, experienced in majority of the state as evident from the rise in water tables reported from Northern districts of the state in the first year of the act. Reduced electricity consumption in agriculture reported by PSEB, substantiates the effectiveness of the act. Taking example from Punjab, the neighbouring state of Haryana has also constituted a similar act. For having maximum adherence of farmers to the act, Government could introduce economic instruments such as differential minimum support price or procurement of paddy only after the stipulated harvesting date. The proven ability of energy policies to regulate groundwater pumping also provide grounds that regulating the irrigation power supply to coincide with the modified cropping calendar would also influence farmers' decision on delaying transplanting date.

The estimates in this study were carried out for medium and long duration varieties of paddy. Lately, there is a shift towards growing of *basmati* (scented rice) variety, influenced by international market demand and reduction in minimum export price for *basmati*. Since late transplanting is mandatory, this would further delay the sowing of wheat. However, resorting to minimum/zero tillage practices could help resolve this problem to a certain extent (Jat et al., 2009).

CONCLUSIONS

The inter-linkage of water-energy-agriculture suggests that any change in one of the components would be accompanied by changes in the other two. Changes introduced to the agricultural system, by means of shifting the transplanting date to periods of low evapotranspiration demands, relate directly to groundwater pumping and can provide a means to preserve this dwindling resource, especially in the overexploited zones of Central Punjab. The study has shown visible estimates of real water savings, which leave little doubt to the potential of this legislative measure introduced by Punjab Government to bring down groundwater overdraft in the region. By creating wet water savings, the

[2] *Electricity subsidies to agriculture in Punjab during 2002-03 was 7% of state expenditures (World Development Report, 2008).*

practice will not only ensures higher t yields but will also improve the water productivity levels.

Energy being one of the key ingredients of agricultural production, this irrigation management initiative would also result in energy savings, especially during the hot summer months when energy demands are at its peak. This article investigated the real water savings, however the total energy savings are likely to be much more, if total irrigation water savings are also taken into accountas well. When indirect energy policy interventions to regulate groundwater pumping such as metering, tariff regulation etc. had been largely unsuccessful, this option appears to be feasible and will rendering positive results within the short time span. The initial results of such an attempt to conserve groundwater are tempting for it to be adopted on a broader scale.

A periodic evaluation is, however, necessary to ensure whether the expected reduction in groundwater depletion is achieved. Delaying the transplanting of paddy also demands research need for early maturing varieties, so as not to affect the sowing time of the following wheat crop. It is suggested that rather than a single way of responding, late transplanting ought to be integrated with other management options for added gains.

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REFERENCES

Arora, V. K. (2006). Application of a rice growth and water balance model in an irrigated semi-arid sub-tropical environment. *Agricultural Water Management.* Vol. 83. pp: 51-57.

CGWB. (2006). Dynamic groundwater resources of India (As on March, 2004). Central Groundwater Board, Government of India.

Chahal, G. B. S., Sood, A., Jalota, S. K., Choudhury, B.U. & Sharma, P.K. (2007). Yield, evapotranspiration and water productivity of rice (Oryza sativa L.)–wheat (Triticum aestivum L.) system in Punjab (India) as influenced by transplanting date of rice and weather parameters. *Agricultural Water Management.* Vol. 88. 14-22.

Jalota, S. K., Singh, K. B., Chahal, G. B. S., Gupta, R. K., Chakraborty, S., Sood, A., Ray, S. S. & Panigrahy, S. (2009). Integrated effect of transplanting date, cultivar and irrigation on yield, water saving and water productivity of rice (Oryza sativa L.) in Indian Punjab: Field and simulation study. *Agricultural Water Management,* Vol. 96. pp: 1096-1104.

Jat, M.L., Gathala,M.K., Ladha, J.K., Saharawat, Y.S., Jat, A.S., Kumar, V., Sharma, S.K., Kumar, V. & Gupta, R. (2009). Evaluation of precision land leveling and double zero-till systems in the rice-wheat rotation: water use, productivity, profitability and soil physical properties. Soil & Tillage Research 105: 112-121.

Mahajan, G., Bharaj, T. S. & Timsina, J. (2009). Yield and water productivity of rice as affected by time of transplanting in Punjab, India. *Agricultural Water Management.* Vol 96. pp: 525-532.

Rodell, M., Velicogna, I. & Famiglietti, J. S. (2009). Satellite-based estimates of groundwater depletion in India. *Nature,* Vol. 460 (7257). Advanced online publication. Available at http://www.nature.com/nature/journal/vaop/ncurrent/full/nature08238.html (Accessed on 13 August 2009).

Sidhu,R.S. & Bhullar, A.S. (2005). Patterns and determinants of agricultural growth in the two Punjabs. *Economic and Political Weekly,* 40(53):5620-27.

Singh, K. (2009). Impact of a legislative initiative on groundwater, electricity subsidy and environment in Punjab. *Paper presented at the 12th Punjab Science Congress*, PAU, Ludhiana on February 7-9, 2009.

Sinha, S., Sharma, B.R. & Scott, C.A. (2006). Understanding and managing the water-energy nexus: Moving beyond the energy debate. In. Sharma, B.R., Villholth, K.G. & Sharma, K.D. (Eds.) Groundwater Research and Management: Integrating Science into Management Decisions, International Water Management Institute, Colombo, Sri Lanka., pp. 242-256.

Virk, G. S. (undated). Management and conservation of irrigation water- Role and programmes of Department of soil & water conservation, Punjab. Available online at http://dswcpunjab.gov.in/contents/data_folder/GSVirk_Paper.htm.