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Water productivity, economics and energetics of *basmati* rice (*Oryza sativa*)–wheat (*Triticum aestivum*) under different methods of crop establishment

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ABSTRACT

A field experiment was conducted to work out the water productivity, economics and energetics of *basmati* rice (*Oryza sativa* L.)–wheat [*Triticum aestivum* (L.) emend. Fiori & Paol] sequence under different methods of crop establishment during 2005-06 and 2006-07. The treatments included combinations of two crop establishment methods of *basmati* rice (direct seeded and transplanted) and three seeding techniques of succeeding wheat (conventional, bed planting and zero tillage). Productivity of *basmati* rice-wheat sequence was significantly higher with transplanted *basmati* rice (TPBR) than direct seeded *basmati* rice (DSBR) irrespective of seeding technique of succeeding wheat. However, crop establishment methods of wheat did not show any significant impact on total productivity of *basmati* rice-wheat sequence during both the years. Total water use was 9.5 and 8.2 per cent higher in TPBR-wheat sequence than DSBR-wheat sequence during 2005-06 and 2006-07, respectively. In this sequence the highest net return was obtained from TPBR-zero till sown wheat sequence, which was closely followed by TPBR-conventionally sown wheat sequence but both gave more net returns than DSBR-zero till sown wheat sequence. The highest energy output was recorded in TPBR-conventionally sown wheat, while energy use efficiency was maximum in TPBR-zero till sown wheat, during both the years because of lowest energy input in zero till sown wheat than conventional and bed planting.

Key words : *Basmati* rice-wheat sequence, Crop establishment methods, Economics, Energetics, Water productivity

Rice and wheat are grown in a sequence on an area about 2.7 million hectares in Punjab and contribute 80% in the total food pool of the state (DAGP, 2011). The total water requirement for rice-wheat system is estimated to vary between 1,382 to 1,838 mm, of which more than 80% is used by rice alone (Jat *et al.,* 2006). Future, food security in this region is severely threatened by over exploitation of groundwater resources and inappropriate water management practices resulting in water table declining at the rate of 70-90 cm per year. Furthermore, cultivation of rice causes serious threats to environment and soil health, mainly due to heavily mechanized land preparation. Lowland rice production destroys the physical structure of the soil which may have adverse implications for the following wheat (Hobbs, 2001). There is an urgent need to divert at least a part of the area under rice to some alternative crops having comparatively low water requirements and reduced tillage needs.

Basmati rice (scented rice) fetches a hefty price in the national as well as international markets due to its excellent cooking and eating qualities. Its growing season coincides with the peak rainy season and hence reduces the dependence on underground water. Traditionally, *basmati* rice is grown by transplanting the seedlings in puddled field, which is vary cumbersome, labour intensive and water exhaustive practice. This technique requires continuous ponding of water during the initial 15 days of seedling establishment and in turn leads to nutrient losses through leaching, besides causing high evapotranspiration losses during the hot summer months. Further, the rising labour cost and lowering of underground water table have compelled to shift from the traditional flooded transplanted to direct seeding of *basmati* rice. As compared to transplanting, direct seeding of rice reduces water consumption up to 13 per cent (Mann *et al.,* 2004), labour cost by 50 per cent (Pandey and Velasco, 1999), matures about 15 days earlier (Gill and Dhingra, 2002). and is conducive for mechanization (Khade *et al*., 1993).

Wheat sowing after *basmati* rice is generally delayed adversely affecting its productivity. Moreover, conven-

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tional sowing of wheat consumes enormous time, in addition to high labour and fuel energy requirement, which further delays wheat sowing and hence poor plant growth and crop yield (Hobbs *et al.,* 1997). As an alternative to the conventional seeding, zero tillage technology ensures early sowing of wheat, conserves irrigation water and reduces the cost of cultivation (Hobbs *et al.,* 1997 and Hobbs, 2001). Bed planting is also gaining importance due to better water management, increased nutrient availability, water use efficiency, better weed management and less compaction. The bed planting system also facilitates better light penetration within the canopy, reduces crop lodging and requires lower seed rate. Thus, present investigation was planned, to study the productivity of *basmati* rice-wheat crop sequence and to compute its water productivity, economics and energetics under different crop establishment methods.

MATERIALS AD METHODS

The field experiment was conducted at Punjab Agricultural University, Ludhiana, during 2005-06 and 2006-07. The soil of the experimental site was loamy sand in texture with pH 8.15 and electrical conductivity of 0.27 (dS/m). The soil was low in organic carbon (0.38%) and available nitrogen (119.4 kg/ha) and medium in available phosphorus (21.5 kg/ha) and potassium (251.5 kg/ha). The field capacity and permanent wilting point of 0-180 cm rhizosphere were 36.89 cm and 11.88 cm, respectively, and average bulk density was 1.63 g/cm^3. The experiment was laid out in randomized complete block design with four replications, consisting combinations of two crop establishment methods of *basmati* rice (direct seeded and transplanted) and three seeding techniques of wheat (conventional, bed planting and zero tillage). The pre-geminated seeds of *basmati* rice i.e. *Basmati* 386 were broadcast in puddled field for establishing direct seeded crop and for nursery raising. Transplanting was done after 30 days at a spacing of 20 cm × 15 cm. The sowing of succeeding wheat was done after a pre-sowing irrigation with tractor drawn zero till and ordinary drill as per treatment using 100 kg seed/ha. Sowing on beds was done with tractor drawn bed planter (2 rows/bed) using 75 kg seed/ha. Both the crops in sequence were raised with recommended package of practices.

Irrigation water applied was calculated by taking depth of each irrigation in centimeter from four representative spots of direct seeded *basmati* rice as well as for nursery. Total irrigation water applied was calculated by adding the depth of water applied in each irrigation for the respective treatments. The energy input and output were calculated for each operation taking standard energy constants as suggested by Panesar and Bhatnagar (1994). Energy use efficiency was calculated by dividing the output with input. Net returns was calculated by deducting the variable cost from gross returns.

RESULTS AND DISCUSSIONS

Productivity and water use

Productivity of a cropping sequence is a function of cumulative economic biomass obtained from different crops grown on the same piece of land during a year. Sequence productivity evaluates the efficiency of various crops to harvest the solar energy while using the available resources optimally. Crop establishment methods of

Table 1. Wheat equivalent yield, water use and water productivity of *basmati* rice-wheat sequence under different methods of crop establishment.

Crop establishment methods in wheat	Wheat yield equivalent (t/ha)			Water use (m^3)			Water productivity (g/m^3)		
	DSBR	TPBR	Mean	DSBR	TPBR	Mean	DSBR	TPBR	Mean
2005-06									
Conventional sowing	8.64	9.02	8.83	22,490	24,610	23,550	384.2	366.5	375.4
Bed planting	8.59	8.89	8.74	22,140	24,260	23,200	388.0	366.4	377.2
Zero-till sowing	8.41	8.83	8.62	22,450	24,570	23,510	374.6	359.4	367.0
Mean	8.55	8.91	-	22,360	24,480	-	382.3	364.1	-
2006-07									
Conventional sowing	8.86	9.08	8.97	24,650	26,670	25,660	359.4	340.5	350.0
Bed planting	8.82	9.00	8.91	24,250	26,270	25,260	363.7	342.6	353.2
Zero–till sowing	8.35	9.36	8.86	24,590	26,610	25,600	339.6	351.7	345.7
Mean	8.68	9.15	-	24,497	26,516	-	354.2	344.9	-
	2005-06		2006-07						
	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)					
CEM* in rice	0.28	1.88	0.36	2.41					
CEM in wheat	1.68	NS	4.04	NS					
Interaction	2.37	NS	5.72	NS		-			-

*crop establishment methods

basmati rice significantly influenced the total productivity of *basmati* rice-wheat sequence, irrespective of planting techniques in wheat, during both the years (Table 1). Transplanted *basmati* rice (TPBR) gave significantly higher wheat yield equivalent than direct seeding of *basmati* rice (DSBR). Ram *et al.* (2006) also reported significantly higher productivity of rice-wheat cropping system with transplanting of rice than direct seeding at Kaul, Haryana.

Planting techniques of wheat did not significantly affect overall productivity of *basmati* rice-wheat sequence. Conventional sowing of wheat produced the higher wheat yield equivalent, which was closely followed by bed planting and zero-till sowing. Irrespective of planting techniques in wheat, TPBR-wheat sequence consumed 9.5 and 8.2 per cent more water than DSBR-wheat sequence, which led to 5.0 and 2.7 per cent less water productivity during 2005-06 and 2006-07, respectively. Thus, DSBR-wheat sequence produced 18.2 and 9.3 g more wheat grain than TPBR-wheat sequence with each cubic meter (m^3) of water during 2005-06 and 2006-07, respectively. Among the planting techniques of wheat, bed planting consumed numerically less water and recorded fractionally higher water productivity than conventional and zero-till sowing during both the years.

Though, the interactive effects between crop establishment methods of *basmati* rice and succeeding wheat were non significant, the maximum sequence productivity (WYE) was recorded under transplanting of *basmati* rice and conventional sowing of succeeding wheat crop. The second best combination was transplanting of *basmati* rice and bed planting of succeeding wheat during both the years of investigation. However, water productivity was the highest under DSBR-bed planted wheat sequence, which was closely followed by DSBR-conventional sown wheat sequence. Thus, TPBR-conventionally sown wheat sequence was more productivity and DSBR-bed planted wheat sequence was more water wise efficient than other treatment combinations.

Economics of basmati rice-wheat sequence

TPBR-wheat gave higher net return than DSBR-wheat (Table 2). This resulted in Rs 0.14 and 0.21 more income from each rupee invested in TPBR-wheat sequence than DSBR-wheat sequence during 2005-06 and 2006-07, respectively. Among the crop establishment methods of wheat zero till sowing gave the highest net returns and benefit cost ratio followed by conventional sowing and bed. This was due to less variable cost under zero till sowing than bed planting and conventional sowing of wheat. The highest net return was obtained from TPBR-zero till sown wheat sequence, which was closely followed by TPBR-conventionally sown wheat sequence and both gave more net return than DSBR-zero till sown wheat. A similar trend was observed for benefit: cost during both the years. Thus, transplanting *basmati* rice followed by zero till or conventional sowing of succeeding wheat was more profitable than direct seeding of *basmati* rice in *basmati* rice wheat sequence.

Energetics of basmati rice-wheat sequence

Transplanted *basmati* rice (TPBR) gave 4.3 and 2.8%

Table 2. Economic analysis of *basmati* rice-wheat sequence under different methods of crop establishment during 2005–06 and 2006–07.

Crop establishment methods in wheat	Variable cost (₹/ha)			Net returns (₹/ha)			Benefit: Cost		
	DSBR	TPBR	Mean	DSBR	TPBR	Mean	DSBR	TPBR	Mean
2005-06									
Conventional sowing	21,805	21,653	21,729	38,675	41,487	80,162	1.77	1.92	1.85
Bed planting	21,570	21,420	21,495	38,560	40,810	79,370	1.79	1.91	1.85
Zero-till sowing	20,052	19,990	20,021	38,818	41,820	80,638	1.94	2.09	2.02
Mean	21,142	21,021	-	38,684	41,372	-	1.83	1.97	-
2006-07									
Conventional sowing	22,416	22,271	22,344	52,894	54,909	1,07,803	2.36	2.47	2.42
Bed planting	22,144	21,999	22,072	52,826	54,501	1,07,327	2.39	2.48	2.44
Zero–till sowing	20,656	20,517	20,587	50,319	59,043	1,09,362	2.44	2.88	2.66
Mean	21,739	21,596	-	52,013	56,151	-	2.40	2.61	-

Price (₹/t)	2005-06	2006-07
Basmati rice	12,500	1,400
Wheat	7,000	850

Table 3. Energetics of *basmati* rice-wheat sequence under different methods of crop establishment during 2005–06 and 2006–07.

Crop establishment methods in wheat	Energy input (MJ/ha)			Energy output (MJ/ha)			Energy use efficiency		
	DSBR	TPBR	Mean	DSBR	TPBR	Mean	DSBR	TPBR	Mean
2005-06									
Conventional sowing	37,198	38,532	37,865	1,27,008	1,32,594	1,29,801	3.41	3.44	3.43
Bed planting	36,631	37,965	37,298	1,26,273	1,30,683	1,28,478	3.45	3.44	3.45
Zero-till sowing	35,622	36,956	36,289	1,23,627	1,29,801	1,26,714	3.47	3.51	3.49
Mean	36,484	37,818	-	1,25,636	1,31,026	-	3.44	3.46	-
2006-07									
Conventional sowing	38,467	39,731	39,099	1,30,242	1,33,476	1,31,859	3.39	3.35	3.37
Bed planting	37,864	39,128	38,496	1,29,654	1,32,300	1,30,977	3.42	3.35	3.39
Zero–till sowing	36,877	38,141	37,509	1,22,745	1,37,592	1,30,169	3.33	3.61	3.47
Mean	37,736	39,000	-	1,27,547	1,31,123	-	3.38	3.44	-

higher energy output than direct seeded *basmati* rice (DSBR), irrespective of crop establishment methods in succeeding wheat (Table 3). A similar trend was observed for energy input, which resulted in not much difference in energy use efficiency of TPBR or DSBR-wheat sequence. Among the seeding techniques of wheat, there was not much difference in energy output, however, the energy input was the lowest when wheat was sown with zero till drill, which nevertheless resulted in higher energy use efficiency during both the years. The highest energy output was recorded under TPBR-conventionally sown wheat in 2005-06 and TPBR-zero till sown wheat in 2006-07, respectively. However, energy use efficiency was maximum under TPBR-zero till sown wheat during both the years of investigation because of lowest energy input under zero till sown wheat than conventional and bed planting. The lowest energy output and energy use efficiency was recorded with DSBR-conventionally sown wheat in 2005-06 and DSBR-zero till sown in 2006-07. In general, TPBR-wheat sequence was more energy efficient than DSBR-wheat cropping sequence.

REFERENCES

DAGP, 2011. Agriculture at a glance 2010-2011. Information service, Department of Agriculture, Government of Punjab.

Gill, M.S. and Dhingra, K.K. 2002. Growing of *basmati* rice by direct seeding method in Punjab. *Indian Farmers' Digest* **35**(6): 13–14.

Hobbs, P.R. 2001. Tillage and crop establishment in South Asian rice-wheat system : Present practices and future options. In: Kataki P K (ed) *The rice-wheat cropping system of South Asia: Efficient production management*. The Haworth Press, New York. pp.85–90.

Hobbs, P.R., Giri, G.S. and Grace, P. 1997. *Reduced and zero-tillage options for the establishment of wheat after rice in South Asia*. Paper Series 2. Rice-Wheat Consortium. CIMMYT, Mexico, DF. pp.18.

Jat, M.L., Chandra, P., Gupta, R., Sharma, S.K. and Gill, M.A. 2006. *Laser land leveling: A precursor technology for resource conservation*. Rice-Wheat Consortium Technical Bull Series 7, New Delhi, India: Rice-Wheat Consortium for the Indo-Gangetic Plains. pp. 48.

Khade, V.N., Patil, B.D., Khanvilkar, S.A. and Chavan, L.S. 1993. Effect of seeding rates and level of N on yield of direct seeded (*Rahu*) summer rice in Konkan. *Journal of Maharashtra Agricultural University* **18**(1): 32–35.

Mann, R.A., Munir, M. and Haqqani, A.M. 2004. Effect of resource conserving techniques on crop productivity in rice-wheat cropping system. *Pakistan Journal of Agricultural Research* **18**(12): 76–82.

Pandey, S. and Velasco, L. 1999. Economics of direct seeding in Asia. Pattern of adoption and research priorities. *International Rice Research News letter* **24**(2): 6–11.

Panesar, B.B. and Bhatnagar, A.P. 1994. Energy norms for inputs and outputs of agricultural sector. (In) : Energy management and conservation in agricultural production and food processing, pp. 5-16. Verma, S.R., Mittal, J.P. and Singh Surendra (Eds). USG Publisher & Distributors, Ludhiana.

Ram, M., Om, H., Dhiman, S.D. and Nandal, D.P. 2006. Productivity and economics of rice (*Oryza sativa*)-wheat (*Triticum aestivum*) cropping system as affected by establishment methods and tillage practices. *Indian Journal of Agronomy* **51**(2): 77–80.