International Journal of Science, Environment and Technology, Vol. 6, No 6, 2017, 3289 – 3298

ISSN 2278-3687 (O)
2277-663X (P)

EVALUATION OF VARIOUS CROP ESTABLISHMENT TECHNIQUES AND MULCHING×IRRIGATION OPTIONS ON GROWTH, YIELD AND PRODUCTION ECONOMICS OF WHEAT UNDER RESTRICTED IRRIGATION

Prantick Singha, Triptesh Mondal, Koushik Patra and Biplab Mitra*
Department of Agronomy, Uttar Banga Krishi Viswavidyalaya, Pundibari, Coochbehar, West Bengal-736165
E-mail: pranticksingha@gmail.com, mtriptesh@gmail.com, koushikpatra55@gmail.com, bipmitra@yahoo.com (**Corresponding Author*)

Abstract: A field experiment was conducted during *rabi*, 2014-15 and 2015-16 at the Instructional Farm of Uttar Banga Krishi Viswavidyalaya, Coochbehar, West Bengal to assess the performance of wheat under various crop establishment techniques and to find out the influence of mulching and irrigation on productivity and profitability of wheat cultivation under restricted irrigation condition. The experiment was laid out in a split plot design having 18 treatment combinations in 3 replications. Three different crop establishment techniques, *i.e.*, Conventional tillage (CT), Zero tillage (ZT) and Bed planting (BP) were randomly allocated in main plots, while six levels of irrigation×mulching were randomly allocated in subplots. It was revealed that the plant height, tiller number as well as LAI at different stages of growth during both the years was found maximum in treatments where mulches were applied @ 4 t ha^{-1} along with three irrigations. All these growth attributes were recorded higher under BP compared to ZT and CT. The total biomass production was recorded significantly higher in BP (8.71 and 8.89 t ha^{-1} during 2015-16 and 2016-17, respectively). In both the years of experimentation, BP recorded significantly higher yield (3.55 and 3.67 t ha^{-1} during 2015-16 and 2016-17, respectively) over CT and ZT. The yield increase under BP was 13.0 and 16.9% over CT during 2015-16 and 2016-17, respectively. As far as the production economics was concerned, the maximum benefit-cost (B: C) ratio (2.25 and 2.41 during 2015-16 and 2016-17, respectively) was recorded under BP. Among mulching×irrigation options, mulching with three irrigations resulted in much superior B: C ratio (2.09 and 2.11 during 2015-16 and 2016-17, respectively) during both the years of investigations. It can be concluded that BP in wheat along with paddy straw mulching @ 4 t ha^{-1} plus 3 irrigations at CRI, booting and milking would be a good option for the farmers in terms of productivity and profitability.

Keywords: Wheat, zero tillage, bed planting, straw mulching.

Introduction

The rice-wheat cropping system of the *Indo-Gangetic Plains* (IGP) is important for food security *vis-a-vis* livelihoods for millions of rural and urban poor in the region. In recent past, a lot of evidences suggest that sustainability of this important system is at risk as the productivity of the system is static for past several years and total factor productivity is

*Received Oct 10, 2017 * Published Dec 2, 2017 * www.ijset.net*

declining due to increasing water scarcity, changing climatic scenario as well as increased labour shortage with escalating fuel prices. There is an urgent need to reduce the cost of cultivation and increase profitability by developing and adopting reduced tillage technologies. Minimum and zero-till technologies for wheat as well as bed planting are beneficial in terms of economics, irrigation water saving and timeliness of sowing in comparison with conventional tillage (Singh *et al.*, 2008). In Northern part of West Bengal, attempts have been made for growing wheat under rainfed condition and it was found that some varieties could successfully be grown under rainfed condition utilizing the residual moisture (Mitra and Das, 2011). Mulching may be a good option here to utilize the residual moisture to its fullest. Moreover, the added benefits will be the reduction in number of irrigation to the crop. With these leads, the present investigation was formulated to study the effects of various crop establishment techniques and mulching options with different number of irrigation on the performance of wheat in terms of growth attributes, yield and production economics under *terai* region of West Bengal.

Materials and Methods

The experiment was conducted in two consecutive seasons, *i.e.*, *rabi*, 2015-16 and 2016-17 at the instructional farm of Uttar Banga Krishi Viswavidyalaya, Pundibari, Coochbehar, West Bengal, India located at 26°24'02.4"N latitude, 89°23'21.7"E longitude and at an elevation of 43 meters above mean sea level. The climate of the experimental site is sub-tropical per humid. The annual precipitation varies from 2800-3000 mm of which 70-90% used to be received during monsoon months (June-September). Minimum temperature is prevailing in December-January and temperature begins to rise from February-March and reaches maximum during April-May (32-35°C). The relative humidity remains very high (80-90%) almost throughout the year except during winter months (50-60%). The experimental soil (0-15cm) was sandy loam in texture (sand 68.00%, silt 20.00% and clay 12.00%) with initial pH 5.80, soil organic carbon 0.88% (high), $KMnO_4$ extractable N 250.88 kg ha^{-1} (low), Bray I P 12.30 kg ha^{-1} (low) and NH_4OAc extractable K 118.62 kg ha^{-1} (low).

The experiment was laid out in split plot design with three replications. Three different crop establishment techniques, *i.e.*, Conventional tillage (CT), Zero tillage (ZT) and Bed planting (BP) were randomly allotted in each main plot, while six treatments comprising irrigation and mulching together, *i.e.*, Straw mulch @ 4 t ha^{-1}+no irrigation (T1); Straw mulch @ 4 t ha^{-1}+1 irrigation at CRI (T2); Straw mulch @ 4 t ha^{-1}+3 irrigations at CRI, Booting and Milking (T3); No mulch+no irrigation (T4); No mulch+1 irrigation at CRI (T5) and No mulch+3

irrigations at CRI, Booting and Milking (T6)were randomly allocated in subplots. The wheat variety used in the experiment was K0307.

Seeds were sown in lines 20 cm apart with a seed rate of 100 kg ha^{-1} for conventional tillage. However, sowing was done in rows 20 and 30 cm apart with 9 tyne zero-till-ferti-cum-seed-drill and 2 wheel drive RWC bed planter for zero tillage and bed planting, respectively with a seed rate of 100 kg ha^{-1} on November 25 and 17 in year I and year II, respectively.

The crop was grown following recommended package of practices. However, in both the years of experimentation irrigations were given based on treatment. Check basin method of irrigation was followed keeping the depth of 4 to 5 cm.

Boron (B) was applied twice @0.20% with *Solubor* (B 20%), once at 35-40 DAS and the next at 55-60 DAS. Zinc (Zn) was applied with B in the second spray, *i.e.*, @ 0.10% with Chelated Zn (Chelamin) in 400 lit water ha^{-1}. Weeds were controlled manually under CT, whereas chemical interventions were followed for ZT and BP.

Growth attributes, *viz.*, plant height, total number of tiller m^{-2}, LAI, total biomass production were taken at periodical intervals while yields were estimated based on net plot basis after drying the seeds to 12% moisture content. Cost of cultivation of various treatments was estimated on the basis of approved market rates for inputs by taking into account the costs of seeds, fertilizers, herbicides, labour charges and hiring charges for machines for seeding. Net income of the farmers was calculated as the difference between gross income and total cost of cultivation. Benefit-cost ratio of different treatments was calculated by taking the ratio of different gross returns (calculated on the basis of support price, *i.e.*, Rs. 15 kg^{-1} for wheat offered by the Government of India) and cost of cultivation.

All the data on growth attributing characters and yields of wheat were analyzed with OPSTAT Windows version for one-way analysis of variance (ANOVA). The significance of various sources of variation was tested by error mean square by Fisher-Snedecorst “F” Test at probability level 0.05. For comparison of ‘F’ tables and for computation of critical differences, Fisher and Yates table was consulted.

Results and Discussion

Growth attributing characters

There was no significant difference in plant height at harvest with respect to crop establishment techniques during both the years of experimentation (Table 1). However, the tallest plant (110.67 and 102.70 cm during 2015-16 and 2016-17, respectively) was recorded under CT. The treatment receiving mulch @ 4 t ha^{-1} and 3 irrigations gave significantly

higher plant height (112.93 and 103.60 cm during 2015-16 and 2016-17, respectively, over the other treatments). Sarwar *et al.* (2013) reported higher plant height in wheat in mulch treated plots.

It was further observed that the total number of tillers m^{-2} was significantly higher in BP compared to CT at 60 days after sowing (DAS), 90 DAS and at harvest during both the years of experimentation. Mulching with irrigation levels had a significant effect on the production of tillers of the crop during both the years of experimentation. The treatment receiving three irrigations along with paddy straw mulching @ 4 t ha^{-1} resulted in higher production of tillers at all the dates. With increase in number of irrigation the number of tillers increased sharply and at the same time considerable difference in tiller number was noticed when mulches were applied in plots. Irrespective of levels of irrigation, the mulched plots recorded significantly higher number of tillers over non-mulch treatments during both the years of experimentation. Optimum moisture availability resulted from irrigation and mulching had a positive effect towards increase in tiller number for wheat. Sarwar *et al.* (2013) reported higher number of tillers under mulch treated plots in wheat under ZT. Among different crop establishment techniques, BP recorded the highest LAI (4.48 and 4.84 during 2015-16 and 2016-17, respectively) at 90 DAS. Significant effect of different irrigation+mulching levels was observed in case of LAI during year I and II of the experimentation. The highest LAI was obtained under plots supplied with three irrigations and rice straw mulching @ 4 t ha^{-1} (5.08 and 5.33 during 2015-16 and 2016-17, respectively). With increasing number of irrigation, the LAI value increased progressively. Again, mulched plots exerted higher LAI value over non mulched plots under all crop establishment techniques during both the years of experimentation (Table 1). This was probably attributed to balanced fertilizer application along with good moisture supply which helped the crop to produce higher leaf area.

Total biomass production at harvest was also found significantly higher in BP (8.71 and 8.89 t ha^{-1} during 2015-16 and 2016-17, respectively). More vigorous growth of the plant with more spike number and higher grain yield under BP and ZT contributed higher biomass over CT. The treatment receiving three irrigations with @4 t ha^{-1} of paddy straw mulch recorded significantly higher biomass production at harvest (10.40 and 10.45 t ha^{-1} during 2015-16 and 2016-17, respectively). Brahma *et al.* (2007) reported higher total dry matter production per plant in wheat under mulched treatment.

Table 1: Growth attributes of wheat as influenced by crop establishment techniques and irrigation×mulching effects

Treatments	Plant height at harvest (cm)		Total number of tillers m^{-2}						LAI 90 DAS		Total biomass production at harvest (t ha^{-1})	
			60 DAS		90 DAS		Harvest					
	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17
Crop establishment techniques*												
CT	110.67	102.70	265	251	310	314	295	300	4.26	4.48	8.36	8.15
ZT	109.73	99.10	268	271	329	337	317	321	4.44	4.79	8.55	8.43
BP	109.17	97.67	285	276	351	347	333	332	4.48	4.84	8.71	8.89
$S.E_m$ (±)	1.72	1.64	5.0	5.3	7.0	7.5	6.5	7.1	0.05	0.06	0.09	0.11
LSD (P=0.05)	NS	NS	20.1	21.4	28.3	30.1	26.2	28.5	0.19	0.24	0.34	0.44
Irrigation×Mulching levels*												
T1	109.27	100.67	228	228	285	303	270	289	3.98	4.25	7.73	7.83
T2	112.00	102.40	301	245	366	320	359	309	4.59	4.89	9.37	9.03
T3	112.93	103.60	358	333	433	430	420	402	5.08	5.53	10.40	10.45
T4	92.93	90.53	210	198	243	237	213	221	3.69	3.95	6.49	6.78
T5	107.80	99.87	245	245	314	325	301	299	4.31	4.58	8.09	7.83
T6	112.27	99.80	268	250	354	347	335	320	4.69	5.00	9.18	8.96
$S.E_m$ (±)	2.45	2.25	8.0	9.4	10.4	12.4	10.5	11.5	0.11	0.22	0.24	0.27
LSD (P=0.05)	7.12	6.56	23.5	27.6	30.4	36.3	30.9	33.8	0.52	0.63	0.70	0.78

*Details of treatments are mentioned in Materials and Methods

Yields and production economics

Perusal of data (Table 2) indicated the superiority of BP in terms of grain yield over ZT and CT. In both the years of experimentation, BP recorded significantly higher yield (3.55 and 3.67 t ha^{-1} during 2015-16 and 2016-17, respectively) over CT and ZT. The yield increase under BP was 13 and 16.9% over CT during 2015-16 and 2016-17, respectively. ZT also recorded significantly higher yield(3.26 and 3.45 t ha^{-1} during 2015-16 and 2016-17, respectively) over CT. BP provided a better environment of growth leading to improved water use efficiency, fertilizer use efficiency as well as reduced infestation of weeds. Moreover, the bed planted crops were less prone to lodging. This was in conformity with the findings of Hobbs *et al*. (2000). Higher grain yields from BP and ZT may be attributed to prolonged soil moisture conservation, proper seed rate and seeding depth, uniform seed distribution, line seeding, less leaching of nutrients, free exchange of gases, and more plant photosynthesis as suggested by Gupta *et al.* (2002). Grain yield increased significantly under mulch treated plots over non-mulched plots irrespective of irrigation levels. The treatments comprising three irrigations along with application of straw mulch @ 4 t ha^{-1} recorded significantly higher yield (4.27 and 4.21 t ha^{-1} during 2015-16 and 2016-17, respectively) over the rest of the treatment combinations in both the years of experimentation.

Straw yield did not differ significantly under various crop establishment techniques as there was not much variation in straw yield achieved under CT, ZT and BP in both the years of experimentation. However, maximum straw yield (5.56 and 5.77 t ha^{-1} during year I and year II, respectively) was achieved under BP, which was statistically *at par* with ZT in 2015-16. Significant variation was found in straw yield under various irrigation with mulching levels. With increase in number of irrigation as well as application of mulch brought about a significant increase in straw yield. The maximum straw yield (6.07and 6.24 t ha^{-1} during 2015-16 and 2016-17, respectively) was obtained in treatments receiving three irrigations along with straw mulching @ 4 t ha^{-1}. It was statistically *at par* with the treatment receiving three irrigations without straw mulching. Harvest index (HI) value was not influenced significantly under various crop establishment techniques during both the years of experimentation. However, it was noted that BP resulted in higher HI value (0.39 in both the years of experimentation) over ZT (0.38 and 0.39 during 2015-16 and 2016-17, respectively) and CT (0.34 and 0.37 during 2015-16 and 2016-17, respectively). It was probably due to slightly higher proportionate grain yield over straw yield resulting from higher grain-straw ratio under BP. HI did not vary significantly under various irrigation combined with

mulching levels during both the years of experimentation. HI was always higher under mulch treated plots (0.38 to 0.41 and 0.40 to 0.41 during year I and II, respectively) compared to non-mulch treatment (0.34 to 0.37 during both the years of experimentation) despite receiving similar number of irrigation. It was also noted that with increase in number of irrigation, harvest index value increased both under mulch treated plots as well as non-mulched plots.

As far as crop establishment techniques were concerned, the cost of cultivation was recorded highest under CT during both the years of experimentation (Rs. 33699 ha^{-1} and Rs. 32987 ha^{-1} during 2015-16 and 2016-17). It was probably due to higher labour cost for land preparation, weeding, fertilizer application etc. No extra cost was incurred towards land preparation both under ZT and BP. Moreover, chemical weed control was performed in these two types of crop establishment techniques which resulted in about Rs. 7000-8000 ha^{-1} of overall savings over CT. Cost of cultivation was increased with increasing levels of irrigation and mulching. Sharma *et al*. (2007) reported that bed planter of wheat saved about 86.1% time as well as 29.8% cost of sowing over conventional method. The net return was found maximum under BP during both the years of experimentation (Rs. 29605 ha^{-1} and Rs. 32192 ha^{-1} during 2015-16 and 2016-17). In case of irrigation along with mulching levels, plots where irrigation was given thrice along with paddy straw mulch recorded the highest net return during both the years of experimentation (Rs. 33467 ha^{-1} and Rs. 33179 ha^{-1} during 2015-16 and 2016-17). Ahmad *et al*. (2013) reported that sowing of wheat in residual moisture through zero tillage technology increased net return on sustained basis.

In general, the treatments having higher net return recorded higher benefit-cost ratio. The maximum benefit-cost ratio (2.25 and 2.41 during 2015-16 and 2016-17, respectively) was recorded under BP during both the years of investigation. With respect to irrigation×mulching levels, the maximum B-C ratio (2.09 and 2.11 during 2015-16 and 2016-17, respectively) was recorded with mulching @ 4 t ha^{-1} and 3 irrigations during both the years of investigation. Naresh *et al*. (2011) reported that the bed planting saved about 72, 62, 84, 78, 84, 34 and 25% in time, labour, fuel, cost, energy, irrigation water and seed and fertilizer compared to conventional sowing and thereby increased the B-C ratio to higher extent.

Table 2: Yield and production economics under various crop establishment techniques and levels of irrigation×mulching

Treatments	Grain yield (t ha^{-1})		Straw yield (t ha^{-1})		Harvest index		Cost of cultivation (Rs. ha^{-1})		Net return (Rs. ha^{-1})		Benefit-Cost ratio	
	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17
Crop establishment techniques*												
CT	3.14	3.14	5.33	5.33	0.34	0.37	33699	32987	13327	14164	1.40	1.43
ZT	3.26	3.45	5.43	5.42	0.38	0.39	25921	25209	23005	26517	1.89	2.05
BP	3.55	3.67	5.56	5.77	0.39	0.39	23596	22884	29605	32192	2.25	2.41
$S.E_m$ (±)	0.03	0.03	0.11	0.19	0.01	0.01	-	-	-	-	-	-
LSD (P=0.05)	0.12	0.13	NS	NS	0.04	NS	-	-	-	-	-	-
Irrigation×Mulching levels*												
T1	2.98	3.16	5.02	4.83	0.38	0.40	28459	27747	16192	19604	1.57	1.71
T2	3.68	3.65	5.70	5.39	0.39	0.41	29184	28472	25967	26229	1.89	1.92
T3	4.27	4.21	6.07	6.24	0.41	0.41	30634	29922	33467	33179	2.09	2.11
T4	2.37	2.46	4.67	4.86	0.34	0.34	25084	24372	10467	16539	1.42	1.68
T5	3.10	3.17	5.32	5.53	0.37	0.36	25809	25097	20692	22504	1.80	1.90
T6	3.49	3.61	5.84	6.19	0.37	0.37	27259	26547	25092	27604	1.92	2.04
$S.E_m$ (±)	0.11	0.12	0.27	0.29	0.02	0.02	-	-	-	-	-	-
LSD (P=0.05)	0.32	0.35	0.77	0.88	0.05	0.05	-	-	-	-	-	-

*Details of treatments are mentioned in materials and methods

Thus, it may be concluded from the above mentioned results that a shift from conventional tillage system to bed planting may break the yield barrier of wheat in *terai* region of West Bengal and could provide maximum profit when combined with paddy straw mulching @ 4 t ha^{-1} along with 3 irrigations under restricted irrigation.

Acknowledgement

The authors are grateful to All India Coordinated Wheat & Barley Improvement Project, UBKV for providing technical support to conduct the field trial.

References

[1] Ahmad, P., Hussain, M., Ahmad, S., Ahmad, M., Tabassam, R. and Shabbir, I. 2013.Comparison of different tillage practices among various wheat varieties. *Applied Science Reports*, **4** (2): 203-209.

[2] Brahma, R., Janawade, A.D. and Palled, Y.B.2007. Effect of irrigation schedules, mulch and anti-transpirant on growth, yield and economics of wheat. *Karnataka Journal of Agricultural Sciences*, **20**(1): 6-9.

[3] Gupta, R.K., Hobbs, P.R., Ladha, J.K. and Prabhakar, S.V.R.K. 2002. Resource Conserving Technologies: Transforming the Rice-Wheat systems of the Indo-Gangetic Plains. (In) *Rice-Wheat Consortium-A success story*.Published by Asia-Pacific Association of Agricultural Research Institutio, FAO Regional Office for Asia and The Pacific Bangkok. pp: 42.

[4] Hobbs, P. R., Singh, Y., Giri, S.G., Lauren, J.G. and Dusbury, J.M. 2000. Direct seeding and reduced tillage options in the rice-wheat systems of the Indo-Gagnetic plains of South Asia. *Paper presented at IRRI workshop ,Bankok, Thailand.*

[5] Mitra, B. and Das, S. 2015. Economization of irrigation schedule in wheat cultivation under sub-*Himalayan* plains of West Bengal. *Journal of Crop and Weed*, **11** (2): 122-126.

[6] Naresh, R. K., Gupta, R. K., Kumar, A., Prakesh, S., Tomar, S. S., Singh, A., Rathi, R. C., Misra, A. K. and Singh, M. 2011. Impact of laser land leveller for enhancing water productivity in Western Uttar Pradesh. *International Journal of Agricultural Engineering*, **4** (2): 133-147.

[7] Sarwar, M.A., Akbar, N., Javeed, H.M.R., Shehzad, M.A., Mehmood, A. and Abbas, H.T.2013. Response of zero tilled wheat crop to different mulching techniques in a semi arid environment. *International Journal of Advanced Research*, **1** (9): 768-776.

[8] Sharma, M.K., Sharma, R.P. and Kumar, R. 2007. Effect of tillage and planting management on field operations and energetics in rice-wheat cropping system. *Journal of Applied Biology*, **17** (1/2): 52-55.

[9] Singh, R.P., Dhaliwal, H.S., Singh, T., Sidhu, H.S., Singh, Y. and Humphreys, E. 2008. A financial assessment of the happy seeder technology for rice-wheat systems in Punjab, India. (In) *'Permanent beds and rice-residue management for rice-wheat systems in the Indo-Gangetic Plain', eds. by E. Humphreys and C. Roth.*