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EFFECT OF DEFICIT IRRIGATION, SOWING METHODS AND MULCHING ON WHEAT YIELD AND NITROGEN UPTAKE

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ABSTRACT:- To determine the irrigation water scarcity, inefficient irrigation supplies to farm lands, increasing temperature with high evaporation rate and poor sowing, an experiment was conducted at the research farm of the University of Agriculture, Peshawar during 2011-12. In the study three factors were studied i.e., sowing methods, mulching and deficit irrigation with four levels viz: full irrigation (DI_0), 20% deficit irrigation (DI_{20}), 40% deficit irrigation (DI_{40}) and 60% deficit irrigation (DI_{60}). Soil moisture was continuously monitored and full irrigation was determined on the basis of 50% Management Allowed Deficit (MAD). Results indicated that sowing methods, mulching and various levels of deficit irrigation significantly ($P<0.05$) affected wheat yield and nitrogen uptake. Raised beds cultivation produced higher number of tillers m^{-2} (415), grain yield (5.13 t ha^{-1}), biological yield (12.02 t ha^{-1}) and total nitrogen uptake (141.7 kg ha^{-1}) as compared to the traditional flat bed. Similarly, mulch plots resulted in higher tillers m^{-2} (404) wheat grain yield (4.94 t ha^{-1}), biological yield (11.94 t ha^{-1}) and total nitrogen uptake (137.6 kg ha^{-1}) than flat bed. In deficit irrigation, maximum tillers m^{-2} (412), wheat yield (5.20 t ha^{-1}), biological yield (11.98 t ha^{-1}) and total nitrogen uptake (144.7 kg ha^{-1}) was recorded at full irrigation application followed by 20% deficit. None of the interactions were found significant.

Key Words: Wheat; Sowing Methods; Mulching; Deficit Irrigation; Nitrogen Uptake; Pakistan.

INTRODUCTION

Water availability per unit irrigated area in Pakistan is declining because of water scarcity, inefficient irrigation system, poor maintenance and low crop water productivity (Ali et al., 2012). On the other hand, country food and fiber demand is increasing with rapid increase in population (Hassan et al., 2005). Wheat is one of the major staple foods of the country and cultivated over 9 m ha (GoP, 2012); its requirement is expected to increase several folds. Thus, situation demands sustainable increase in crop yield per unit area with scarce water resources. Deficit irrigation (DI) is a type of irrigation management strategies in which water is applied below full crop-water requirements, and is a vital tool for enhancing water use efficiency in closely spaced crops like wheat without causing severe yield reduction (Zhang et al., 2004). According to Pereira et al. (2002), there is only 13% reduction in wheat

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yield in response to water application up to 40% less than full potential crop water requirement. Wheat yield reduction through DI could be alleviated by adopting different management techniques like drought stress cultivars, suitable sowing method, maintaining fertility status, and mulching as well. But appropriate sowing method and soil moisture conservation practice by mulching are the most important ones. Raised bed planting method is suitable for wheat cultivation and proved to be one of the available options for saving water through attaining high water use efficiency. Raised bed cultivation is responsible for increasing 14-21% wheat yield with 13-45% higher crop water productivity than traditional flatbed cultivation (Akbar et al., 2009). Raised beds wheat plantation improves yield, increases fertilizer use efficiency, reduces herbicide use and saves seed as well. Mulching increases crop water productivity by retaining the moisture contents in the soil, decreasing soil evaporation and increasing crop transpiration (Ahmed et al., 2007). Deficit irrigation coupled with appropriate sowing methods and mulching can be a good option to save water. Scientists have experimentally tested these technologies individually; however, collective effects of sowing methods and mulching in combination with DI have not been thoroughly investigated. Therefore, a study was conducted to determine the optimum, efficient and economical amount of irrigation, proper sowing method and mulch for wheat production. The research findings are expected to be useful for wheat farmers, water users and planners to make economical and efficient use of available irrigation water.

MATERIALS AND METHOD

The experiments were conducted at the research farm of The University of Agriculture, Peshawar, Khyber Pakhtunkhwa located at 34.02° N and 71.18° E with an elevation of 450 m above the sea level during the wheat crop growing season (Nov- Apr) 2011-12. Climatically Peshawar is warm to hot, semi-arid and subtropical with mean annual temperature of 26.3°C and average annual rainfall of 445 mm. The weather data during the experimental period was collected from Pakistan Meteorological Department (PMD), Peshawar (Figure 1). Soil samples from 0-30, 30-60 and 60-100 cm were collected and analyzed for various chemical and physical properties (Table 1). The soil of the experimental site was silty clay loam with 30% field capacity, 18% permanent welting point and 14 cm m^{-1} available water. A Randomized Complete Block Design (RCBD) with split-split plot arrangement having four replications and two sowing methods namely: flat bed (FB) and raised bed (RB). The width of the raised bed was kept 125 cm from furrow to furrow and its top width was 80 cm while it was 25 cm high from ground level. Treatments were with (M1) and without Mulch (MO). Maize stover was used as mulch at 4 t ha^{-1} and treatments were: i) Full irrigation (DI_0), ii) 20% deficit (DI_{20}) iii) 40% of deficit (DI_{40}) iv) 60% deficit (DI60). For irrigation water from Warsak Gravity Canal was used and the flow rate was measured by a cutthroat flume

(3"x4") installed at the inlet of the experimental plots. To apply the measured quantity of irrigation water, each plot was irrigated separately. Full irrigation was determined on the basis of MAD 50% and soil moisture was continuously monitored at a weekly interval with the help of Gravimetric method (Khan et al., 2007). When the soil of the experimental field reached field capacity, wheat variety Seran 2010 was sown @ 120 kg ha^{-1}. In the raised beds, it was sown with the help of raised bed machinery while in flat beds it was sown with the help of seed drill. The recommended rate of NPK (120-90-60 kg ha^{-1}) was applied to all plots through broadcasting. Full P and K and half N were applied before sowing and the remaining half of N was applied with the second irrigation. The data on number of tillers m^{-2} were recorded by throwing one 1m^2 quadrate in the center of the each subplot and the tillers fallen under the quadrate were uprooted, identified and separated. Data regarding plant height, grain yield and biological yield was recorded.

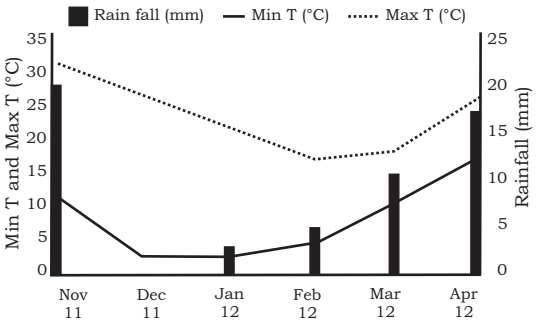

Figure 1. Monthly temperature and total rainfall of the study area during 2011-12

Table 1. Soil physical and chemical properties of experimental field

Characteristic	Status
Sand (%)	18.40
Clay (%)	31.10
Silt (%)	50.50
Texture class	Silty clay loam
pH	7.90
EC (dSm^{-1})	0.21
Bulk density (g cm^{-3})	1.54
Field capacity (%)	32.00
Permanent Welting Point (%)	18.00
Available Water (cm m^{-1})	14.00
Organic matter (%)	0.43
Total N (%)	0.07

Statistical Analysis

The data recorded were analyzed statistically using analysis of variance techniques appropriate for a RCBD. Means were compared using the LSD test at 0.05 level of probability, when the F-values were significant (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Yield and Yield Components

The statistical analysis of the research data showed that different sowing methods, application of crop residues as mulch and various deficit irrigation levels has significantly affected wheat grain yield and yield attributes (Table 2). Raised beds resulted in higher number of tillers (415 m^{-2}), grain yield (5.13 t ha^{-1}) and biological yield (12.02 t ha^{-1}) as compared to flat bed. That might be probably due to better sunlight

penetration, good environmental conditions for seed germination, and higher water use efficiency under raised beds (Mollah et al., 2009). These results are in agreement with Shah et al. (2013) who reported higher grain yield and its component under raised beds.

The use of surface mulch resulted in higher tillers (404 m^{-2}), wheat grain (4.94 t ha^{-1}) and biological yield (11.94 t ha^{-1}) than no-mulch plots. The application of maize residues results in reduced evaporation, lower weed infestation and higher soil organic matter which on decomposition improve soil fertility (Singh et al., 2013). Improved soil fertility might be the reason for better yield and yield components. Another reason for better plant growth could be the higher nutrients contents (6% crude protein and about 1% nitrogen) in maize stover (Fakher et al., 2012). These results are in line with Shafi et al. (2010) who reported that application crop residues as mulch resulted in improved soil productivity and higher grain yield.

Full irrigation resulted in higher number of tillers (412 m^{-2}), taller plants (98.5 cm), and biological yield (11.98 t ha^{-1}) as compared to 60% deficit. The reason might be the better seed germination under favorable moisture condition. The wheat grain

Table 2. Effect of sowing methods, mulching and deficit irrigation on yield and yield components of wheat during 2011-12

Treatments		Tillers (m^{-2})	Plant Height (cm)	Grain yield (t ha^{-1})	Biological yield (t ha^{-1})
Sowing method (SM)	Raised Bed	415	95.8	5.13	12.02
	Flat Bed	372	95.3	4.45	11.05
	Significance	*	ns	*	*
Mulch (M)	No-mulch	404	96.2	4.63	11.94
	Mulch	383	94.8	4.94	11.13
	Significance	*	ns	*	*
Irrigation (DI)	DI_0	412 [a]	98.5 [a]	5.20 [a]	11.98 [a]
	DI_{20}	400 [a]	97.0 [b]	5.10 [a]	11.80 [a]
	DI_{40}	387 [b]	95.3 [c]	4.73 [b]	11.46 [b]
	DI_{60}	375 [c]	91.3 [d]	4.13 [b]	10.46 [c]
	LSD	12.9	1.2	0.26	00.23
Interactions	SM x M	s	ns	ns	ns
	DI x SM	s	ns	ns	ns
	DI x M	s	ns	ns	ns
	DI x SM xM	s	ns	ns	ns

** Significant at 5 % probability level.*

yield was significantly affected by DI levels beyond 20% . Full irrigation application resulted in higher wheat grain (5.20 t ha^{-1}) yield followed by 20% DI (5.10 t ha^{-1}) which is only 2% less than the maximum. While, application of 40% and 60% deficit irrigation resulted in 10% and 25% lower grain yield as compared to full irrigation, respectively.The reasons might be the higher number of tillers m^{-2}, less water stress and higher water use efficiency achieved at full irrigation and 20% deficit (Kilic et al., 2010). These results are in agreement with Warraich et al. (2011) who reported lower wheat grain yield under water stress conditions due to strong water potential where plants requires more energy for taking water from low moist soil.

Total Nitrogen

Analysis of the data showed that sowing methods, mulch and deficit irrigation has significant effect on total nitrogen uptake in wheat crop (Table 3). Higher total nitrogen uptake was recorded at raised beds (141.7 kg ha^{-1}) and mulch plots (137.6 kg ha^{-1}) as compared to flat bed (120.6 kg ha^{-1}) and no-mulch plots (124.7 kg ha^{-1}). The higher results were probably due to better soil environment and nitrogen mobilizations and its availability for plants (Shafi et al., 2010). These are supported by Pervaiz et al. (2009) who reported higher N uptake under mulching because of its high nutrient contents.

Application of full irrigation resulted in higher total nitrogen uptake (144.7 kg ha^{-1}) in wheat crop compared to 60% DI (110.4 kg ha^{-1}) but there was no significant difference between full irrigation and 20% DI (141.0 kg ha^{-1}). Thus, besides saving irrigation water, 20% DI is helpful in preclusion of runoff, volatilization, denitrification and prolong vegetative growth without compromising nutrients uptake. It is obvious from the data that DI after a certain level decreased total nitrogen uptake up to 30% compared to the maximum uptake. In severe water stress conditions, high osmotic stress and nitrogen instability are the most possible reasons for lower nitrogen uptake in crops (Kadeer et al., 2007). These results are in agreement with the earlier findings of Ehsanullah et

Table 3. Effect of sowing methods, mulching and deficit irrigation on total nitrogen uptake in wheat crop during 2011-12

	Treatments	TN (%) Rain	TN (%) Straw	TN (g ha^{-1})
Sowing method	Raised	2.05	0.60	141.7
	Flat	2.02	0.53	120.6
	Significance	*	*	*
Mulch (M)	Mulch	2.06	0.57	137.6
	No-mulch	2.01	0.55	124.7
	Significance	*	*	*
Irrigation (DI)	DI_0	2.10 a	0.60 a	144.7 a
	DI_{20}	2.06 ab	0.58 b	141.0 a
	DI_{40}	2.04 b	0.55 c	128.4 b
	DI_{60}	1.96 c	0.53 d	110.0 c
	LSD	0.05	0.015	3.7
Interactions	SM x M	s	ns	ns
	DI x SM	s	ns	ns
	DI x M	s	ns	ns
	DI x SM xM	s	ns	ns

** Significant at 5 % probability level.*

al. (2013). The interactive effect of sowing method, mulching and deficit irrigation was found non- significant.

It is concluded that in semiarid environment like Peshawar adaptation of raised beds technology, application of crop residues as surface mulch and irrigation water stress up to 20% is helpful in saving irrigation water without compromis-ing wheat grain yield and nutrients uptake.

LITERATURE CITED

Ahmed, Z. I., M. Ansar, M. Iqbal, and N. M. Minhas. 2007. Effect of planting geometry and mulching on moisture conservation, weed control and wheat growth under rainfed conditions. Pakistan J. Bot. 39(4): 1189-1195.

Akbar, G., G. Hamilton, and Z. Hussain. 2009. Permanent raised bed cropping system improves water use efficiencies of wheat and maize crops, Mardan, Pakistan experience. Pakistan. J. Water Resources. 13(1): 12-16.

Ali, M., L. Ali, M. Q. Waqar and M. A. Ali. 2012. Bed planting: A new crop establishment method for wheat in cotton-wheat cropping system of southern Punjab. Inter. J. Agric. Appl. Sci. 4(1): 87-92.

Ehsanullah, S. Shakeel and A. Ghaffar. 2013. Impact of tillage and mulch on water conservation in wheat (*Triticum aestivum* L.) under rice-wheat cropping system. J. Agric. Res. 51(3): 255-260

Fakher, I., M. Iqbal and T. Azeem. 2012. Impact of crop residue mulching on performance of wheat. J. Agric. Sci. 3: 191-199.

GoP. 2012. Ministry of Food, Agriculture and Livestock. Economic Wing, Government of Pakistan , Islamabad, Pakistan.

Hassan, T., G. Jilani. J. F. Parr and R. Ahmad. 2005. Transition from conventional to alternative agriculture in Pakistan. Am. J. Altern. Agric. 10(3): 133-137.

Kadeer. A. E., A. Shaaban and M. S. Fattah. 2007. Effect of irrigation levels and organic compost on okra plants grown in sandy calcareous soil. Agric. and Bio. J. 263-267.

Khan, M. A., M. Shafeeq and I. Awan. 2007. Water and energy inputs for wheat production under permanent raised beds. Sarhad. J. Agric. 23(3): 31-36.

Kilic, H., 2010. The effect of planting methods on yield and yield components of irrigated spring durum wheat varieties. Sci. Res. Ess. 5(20): 3063-3069.

Mollah, M., U. Bhuiya and M. H. Kabir. 2009. Bed planting, a new crop establishment method for wheat in rice-wheat cropping system. J. Agri. Rural Dev. 7(1-2): 23-31.

Pereira, L. S., T. Owais and A. Aziz. 2002. Irrigation management under water scarcity. Agri. Water Manag. 57(3): 175-206.

Pervaiz, M. R., M. Iqbal and K. Shahzad 2009. Effect of mulch on soil physical properties and N, P, K concentration in maize shoots under two tillage systems. Inter. J. Agric. and Bio. 11(2):119-124.

Shafi. M., J. Bakht, Attaullah, and M. A. Khan. 2010. Effect of crop sequence and crop residues on soil c, soil n and yield of maize. Pakistan. J. Bot. 42(3): 1651-1664.

Shah, S. H., A. Hassan, A. Ghafoor and A. Bakhsh. 2013. Soil physical characteristics and yield of

wheat and maize as affected by mulching materials and sowing methods. Soil Sci. Soc. Pakistan. 32(1): 14-21.

Singh, H., H. K. Sachan and D Krishna. 2013. Effect of irrigation scheduling on NPK concentration, uptake, yield and yield attributing characters of zero tilled wheat. Inter. J. Agric. Sci. Res. 3(2): 239-244.

Steel, R. G. D., and J. H. Torrie. 1980. Principles and procedures of statistics. 2nd edition. McGraw Hill, New York.

Warraich. E. A., R. Ahmed and M. Y. Ashraf 2011. Role of mineral nutrition in alleviation of drought stress in plants . Aust. J. Crop Scie. 5(6): 764-777.

Zhang, Y., E. Kindly and S. Aweis. 2004. Effect of soil water deficit on evapotranspiration, crop yield and water use efficiency in North China. Agric. Water Manag. 64: 107-122.

AUTHORSHIP AND CONTRIBUTION DECLARATION

S.No	Author Name	Contribution to the paper
1.	Dr. Abdul Razaq	Conceived the idea, Results and Discussion, Conclusion, Data collection
2.	Dr. Muhammad Jamal Khan	Overall management of the article, Data entry in SPSS and analysis
3.	Dr. Tahir Sarwar	Technical input at every step
4.	Dr. Mohammad Jamal Khan	Introduction, References, Wrote abstract, Methodology

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