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- **Education Background:**

  2005 Ph.D., Crop Science, Shandong Agricultural University, China
  2000 M.S., Crop Science, Shandong Agricultural University, China
  1997 B.S., Agronomy, Shandong Agricultural University, China

- **Working Experiences:**

  2020.05-present Professor, College of Agronomy, Northwest A&F University, Yangling, Shaanxi, China
  2010.07-2020.04 Professor, State Key Laboratory of Crop Biology, Shandong Agricultural University, Taian, Shandong, China
  2016.10-2017.10 Visitor scientist, Department of Agronomy, Kansas State University, Manhattan, KS 66506, USA
  2011.03-2011.08 Visitor scientist, The James Hutton Institute, Invergowrie, Dundee DD2 5DA, Scotland UK
  2006.07-2010.06 Associate professor, State Key Laboratory of Crop Biology, Shandong Agricultural University, Taian, Shandong, China
  2002.07-2006.06 Lecturer, College of Agronomy, Shandong Agricultural University, Taian, Shandong, China
  2000.07-2002.06 Teaching Assistant, Department of Agronomy, Shandong Agricultural University, Taian, Shandong, China

- **Research Interests:**

Theory and technology of precise regulation and control of water and fertilizer in wheat and maize; physiological and biochemical responses of wheat to drought tolerance and irrigation;

Theory and technology of green and efficient cultivation of wheat in arid and semi-arid areas; Food chemistry of specialty pasta in northwest China, and biological mechanism of grain yield and quality formation in wheat. Physiological and ecological mechanisms of spike formation, senescence and matter redistribution after anthesis in wheat.

- **Professional Activities:**

Peer reviewer of numerous scientific journals and governmental funding agencies
Leader of innovation team of crop cultivation and tillage technology standards in arid and semi-arid areas

Leading talents in Ten Thousand Plan-National high-level Special Support Plan, Ministry of Human Resources and Social Security of the People's Republic of China, 2018-02

Young & Middle-aged Leading Science and Technology Innovation Talent of China, Ministry of Science and Technology of the people's Republic of China, 2016-05-16

Middle-aged and young expert with outstanding contribution in shandong province, Shandong province people's government, 2013-04-17

The Governmental Special Subsidy of 2008 by the State Council (Certificate No. 08-9370066), 2008-10-1.

Deputy head of wheat group in Crop Science Society of China (2010-2016);

The member and secretary of the Ministry of Agriculture Wheat Experts Committee (2012-2018)

Shandong Provincial Youth Science and Technology Award, 2008-5-7.

The 2nd Prize of the National Sci-Tech Advance Award: Quality physiology basis and cultivation theory and technology of high quality and yield in wheat (Certificate No. 2006-J-201-2-15-R02), 2007-2-11.

The 2nd Prize of the National Sci-Tech Advance Award: Senescence physiology and cultivation theory and technology of super high yield in wheat (Certificate No. J-201-2-03-R07), 2001-12-19

Leader of two projects supported by the National Natural Science Foundation of China (No. 30800673, 2009.1-2011.12 and No. 31271660, 2012.1-2016.12), and one project supported by the the Special Fund for Agro-scientific Research in the Public Interest of China (No. 201503130, 2015.1-2019.12).

On-demand irrigation achieved high WUE and NUE and grain yield of winter wheat by regulating root vertical distribution

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Abstract: **【Objective】** The winter wheat (Triticum aestivum L.) production of the North China Plain is threatened by increasing water shortages. Therefore, the invention of effective irrigation techniques is crucial to maintain high yields of winter wheat through improved water use efficiency (WUE). **【Method】** In this study, field experiments were carried out in the North China Plain region in 2012-2013 and 2013-2014. Based on the soil moisture regulation at sowing to ensure the normal emergence of the winter wheat, four supplemental irrigation (SI) regimes were set up: no-irrigation after emergence (T1), SI at jointing and anthesis (T2), SI at sowing, jointing and anthesis (T3), and SI at pre-wintering, jointing and anthesis (T4). **【Result】** The results showed that the root length density (RLD), root surface area density (RAD), and root weight density (RWD) in the 0-0.2 m soil layer from T2 increased rapidly after jointing and were significantly higher than those from T3 and T4 at anthesis. Those of T2 in the 0.6-0.8 m and 0.8-1.0 m soil layers were also significantly higher at anthesis. T2 was significantly higher than T1 in the photosynthetic rate (Pn) and instantaneous water use efficiency (WUEleaf) of flag leaves, post-anthesis dry matter accumulation (DMA), contribution of DMA to grain (CDMA), grain yield and WUE, but lower than T1 in the pre-anthesis dry matter remobilization efficiency (DMRE) and contribution of DMR to grain (CDMR). T2 had significantly lower plant populations and dry matter at jointing, Pn and WUEleaf at 28 days after anthesis, DMA and CDMA, but higher dry matter increase rate after jointing, tiller survival rate, DMR, DMRE, CDMR and WUE. The combined effect of these differences enabled T2 to have yield that was not significantly different to T4. In summary, SI at joining and anthesis that was based on suitable soil water content at sowing increased the absorbing area of roots in both deep and surface soil layers; accelerated the dry matter accumulation after jointing; increased the Pn and WUEleaf of flag leaves, DMA and DMR; and finally achieved a high grain yield and higher WUE. However, excessive irrigation reduced the WUE by inhibiting the redistribution of dry matter, although the WUEleaf of flag leaves was still increased.

Crop nitrogen (N) uptake depends on the root absorption area and the soil N availability which are closely related to the soil water status. With the increasing water shortages in the North China Plain, supplemental irrigation (SI) to winter wheat is a promising technique. To clarify the relationships between water and nitrogen use, four SI regimes in Tritcum aestivum L. cv. Jimai 22 were set up: no-irrigation after emergence (T1), SI at jointing and anthesis (T2), SI at sowing, jointing, and anthesis (T3), and SI at pre-wintering, jointing, and anthesis (T4). The results indicate that T2 had higher root length density (RLD) and root surface area density (RAD) in the 0-20, 60-80, and 80-100 cm soil layers, as well as higher post-anthesis N

uptake from soil by 23-26% in 2012-2013 and 162-177% in 2013–2014, compared to T3 and T4. The grain yield under T2 was lower than T3 but was not significantly different from T4, whereas its water use efficiency (WUE) was higher relative to both T3 and T4. There were no significant differences among T2, T3, and T4 in N use efficiency (NUE). The N uptake after jointing and WUE were positively correlated with the RLD and RAD in the 0-20 cm soil layer. The NUE was positively correlated with the RLD and RAD in the 20-40 cm soil layer. 【**Conclusion**】These results indicate that timely SI at jointing and anthesis was dependent on a suitable water supply at sowing, which increased the soil water content in the upper soil layer after jointing and improved the absorption area of the roots in both the deep and surface soil layers; this further improved the post-anthesis N uptake from the soil and the WUE. This approach can be a valuable way to maintain high grain yields and NUE in winter wheat while using less irrigation and achieving higher WUE in the North China Plain.