Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

J P P Journal of Pharmacognosy and Phytochemistry

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2019; 8(1): 1587-1591
Received: 21-11-2018
Accepted: 24-12-2018

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Nutrient uptake, fertilizer use efficiency and cost of cultivation of wheat (*Triticum aestivum*) under drip irrigation

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Abstract
A field study was investigated in 2016-17 at G.B. Pant University of Agriculture and Technology, Pantnagar, to study the effect of drip irrigation on nutrient uptake and nutrient use efficiency of wheat (*Triticum aestivum*). The experiment was carried out in RBD with eight treatments and four replications. Results revealed that the uptakes of nutrients (NPK) were significantly higher recorded in T_5 (N- 130.86 kg ha^{-1}, P- 31.47 kg ha^{-1} and K- 144.50 kg ha^{-1}) and lower in T_2 treatment (N- 96.13 kg ha^{-1}, P- 19.68 kg ha^{-1} and K- 109.46 kg ha^{-1}). Result further revealed that use efficiency of nutrients was higher in the treatments of T_5 (23.30) and T_4 (22.18) where water supply with 100 and 75% CPE respectively through drip irrigation at two days interval. Maximum nitrogen use efficiency was observed in T_5 (19.58, 0.51 and 37.85) in terms of AEN, REN and PEN. Highest grain yield was found in T_5 (5825 kg ha^{-1}). In terms of economy highest B: C ratio was obtained with treatment T_5 (3.57).Compare to farmer practice (T_2) all the drip irrigated treatments results significant benefit in terms of nutrient use efficiency and economy.

Keywords: CPE, Drip irrigation, efficiency, fertigation, nutrient uptake

Introduction
Wheat (*Triticum aestivum*) is the second important staple crop after rice in India. Currently, India is the second largest producer of wheat in the world after China. In India, it is grown on an area of about 30 million ha with a production of 93 million tons (Directorate of Economics and Statistics, Government of India, 2014). The average national productivity is about 2.98 t/ha. Wheat crop in India is grown during winter months when rains are normally scarce. It mainly depends on the supplementary irrigation for its water use. Irrational irrigation practice leads to either under or over irrigation. Therefore, to maintain the optimum soil moisture in the root zone of the wheat crop, it is important to work out an effective and economic schedule of irrigation under a given agro-climatic zone. Micro-irrigation, especially drip irrigation system can control the rate of water application to achieve application efficiency as high as 90-100%.Meanwhile, water demand is continually increasing due to population growth, industrial development and the increase of living standards. Because of population growth, the per capita share of water has dropped dramatically. This brings us the message that with increasing population and demand for food production under resource-poor situations where agriculture becomes more and more competitive, cultivation must be geared to achieve higher productivity (yield per unit land and /or water resource) in order to meet the market demand for the commodity. Unlike surface and sprinkler irrigation, the drip system can keep the soil water content always near the field capacity without creating any soil moisture deficit to the crop. Drip irrigation systems are designed to apply only the required amount of water. Therefore, it would minimize water losses from runoff, percolation, and seepage. This would be the crux for future green revolution and food security through water and energy security. Fertigation technique, which helps in the application of water soluble fertilizers along irrigation water with maximum uniformly and more efficiently. It is advised that fertilizer should be applied regularly and timely with a small quantity, which facilitates to increase the use efficiency of applied nutrients and minimizes leaching losses. Because of these advantages, nutrient application through drip fertigation is getting popularity among farmers for many crops (Pawar *et al.*, 2013) [5]. Compared to the conventional fertilization, new fertilization technologies result in higher nutrient uptake (Patil *et al.*, 2001) [6] which not only increases water and nutrient use efficiency but also increases crop yield and quality with lesser costs and increase the crop production efficiency (Li and Yang, 1993) [4]. The number of tillers per plant and thousand seed weight mainly affect the wheat grain yield which is mainly influenced by water and nutrient availability in the root zone. At grain development stage, nutrient addition through drip, fertigation increases the number of spikelets per spike.

In irrigated condition, appropriate management techniques and skills related to the application of water and nutrients are required for obtaining better yields and crop quality. As water and nutrients are costlier inputs, for its efficient utilization scientific means need to be developed.

Keeping all these points in view the present experiment was conducted to work out the feasibility of drip irrigation in wheat, its influence on nutrient uptake, nutrient use efficiency and productivity of wheat.

Materials and methods

The field experiment was conducted at 'H' Block of University Farm, G.B. Pant University of Agriculture and Technology, Pantnagar, India during the *Rabi* season 2016-17. Pantnagar is located at 29º N latitude, 79^0.29'E longitude and at an altitude of 243.84 meters above mean sea level. During the experimental period year, the mean maximum and minimum temperature were 35.31 and 4.28 º C, respectively, mean relative humidity was maximum 93% in morning and minimum 20% in evening, total rainfall received during the crop life was 76.2 mm. The experimental soil was classified as mollisol. The soil was silty clay loam with high in organic carbon and available P and medium in K and low in available N having neutral to alkaline in reaction.

The experiment was laid out in randomized block design with four replications. The treatments were consisted of eight treatments conventional and drip irrigation practices for wheat crop. A conventional irrigation practice includes wheat grown without fertilizers as absolute control (T_1) with fertilizers as farmer's practice (T_2) and six drip irrigation treatments consisted of 50%, 75%,100% cumulative pan evaporation (CPE) at 2 days and 4 days interval. Whereas, under drip irrigation method, irrigation provided at 50% CPE on two days interval (T_3); at 75% CPE on two days interval (T_4); at 100% CPE on two days interval (T_5); at 50% CPE on four days interval (T_6); at 75% CPE on four days interval (T_7) and at 100% CPE on four days interval (T_8).

Wheat variety WH-1124 was sown in November 2016 with seed rate 100 kg ha^{-1} at 20 cm row spacing and with recommended package of practices. Irrigations were applied through drip irrigation based on daily pan evaporation values were measured with the help of USWB class 'A' open pan evaporimeter installed in the Crop Research Centre of university. While, in conventional method, 5 irrigations were applied with 6cm depth of water in each irrigation at critical growth stages. The amounts of irrigation water by one lateral in different irrigation treatments were calculated as

$$\text{Time of operation (Hours)} = \frac{\text{Volume of water to be delivered (V) by one lateral (l)}}{\text{Emitter discharge rate (lpH) x Number of emitters}}$$

$V = r.\ E_o.\ K_{pan}.\ K_c.\ A$

Where, V - Volume of water to be delivered by one lateral (lpH), E_o is USWB open pan evaporation (mm/day), K_{pan} is Pan coefficient, K_c is Crop co efficient, r is Unit constant, A is Area covered by one lateral (m^2). Then, time of operation of drip system to deliver the required volume of water per lateral as per the irrigation treatment was computed based on the formula.

For conventional irrigation, the entire quantity of phosphorus (60 kg ha^{-1}) in the form of DAP and potash as MOP along with 50 percent of nitrogen were applied uniformly in the furrows as basal dose. The remaining 50 percent of nitrogen was applied as top dressing at tillering stage as per treatments. While in drip system, fertigation with uniform dose of 150 kg N, 60 kg P_2O_5 and 40 kg K_2O ha^{-1} was applied through water soluble fertilizers viz., urea (46% N), phosphoric acid (60% P_2O_5) and white potash (60 % K_2O). Fertigation schedules followed in the experiment are presented in (Table 1). All the cultural operations were carried out as per recommendations.

Nutrient Use Efficiency (NUE)

The nutrient use efficiency (kg grain/ kg nutrient applied) was computed as described by Veeranna (2001) [10].

$$\text{NUE} = \frac{\text{Yield(kg/ha)}}{\text{Total quantity of nutrient applied(kg/ha)}}$$

Assessment of nitrogen use efficiency

The following expressions were used for determining terms related to nitrogen use efficiency which were calculated by using the formula described by Cassman *et al*., 1998.

The formula described below is given for calculation of above parameters with respect to nitrogen.

a) Agronomic efficiency

It was expressed as kg grain yield increase kg^{-1} N applied.

$$\text{AE} = \frac{\text{Grain yield kg ha}^{-1}\text{ (with applied N) - Grain yield kg ha}^{-1}\text{ (without N)}}{\text{Amount of N fertilizer applied (kg ha}^{-1})}$$

b) Recovery efficiency

It was expressed as percent increase N uptake kg^{-1} N applied.

$$\text{RE} = \frac{\text{Total N uptake (kg ha}^{-1}\text{) in N fertilized plot - Total N uptake (kg ha}^{-1}\text{) in control plot}}{\text{Amount of N fertilizer applied (kg ha}^{-1})}$$

c) Physiological efficiency

It was expressed as kg grain kg^{-1} N uptake.

$$\text{PE} = \frac{\text{Grain yield kg ha}^{-1}\text{ (with applied N) - Grain yield kg ha}^{-1}\text{ (without N)}}{\text{Total N uptake (kg ha}^{-1}\text{) in N fertilized plot - Total N uptake (kg ha}^{-1}\text{) in control plot}}$$

The uptake was calculated by using following formula and expressed as kg ha^{-1}

Total 'X' uptake (kg ha^{-1}) = 'X' uptake by grain (kg ha^{-1}) + 'X' uptake by straw (kg ha^{-1})

$$\text{'X' uptake by grain (kg ha}^{-1}) = \frac{\text{'X' conc. in grain (\%)} \times \text{Grain yield (kg ha}^{-1})}{100}$$

$$\text{'X' uptake by straw (kg ha}^{-1}) = \frac{\text{'X' conc. in straw (\%)} \times \text{Straw yield (kg ha}^{-1})}{100}$$

Where, 'X' is N, P and K

The crop was harvested manually and data on test weight, grain yield, straw yield and harvest index were recorded. The sun-dried bundles were threshed and winnowed and grains obtained were weighed.

Economic analysis

Common cost of production ha^{-1} was computed by summing up all the expenditure, except the cost of drip irrigation system. Adding the expense of different drip treatments to the common cost of production ha^{-1} was the production cost ha^{-1} for different treatments.

Gross return ha^{-1} for different treatments was computed by multiplying the yield (both grain and straw) to their respective

prices. Net returns ha^{-1} was calculated by subtracting the total cost of production from gross returns ha^{-1} for different drip treatments. For different treatments the net return in terms of rupees was calculated by dividing the net returns ha^{-1} with the cost of production ha^{-1} which describes the efficiency of capital used.
B: C ratio was computed as follows:

$$\text{Benifit Cost Ratio (B: C ratio)} = \frac{\text{Net return}}{\text{Cost of cultivation}}$$

The obtained data were statistically analysed by two-way Analysis of Variance (ANOVA) following the method of Gomez and Gomez (1984).

Results and discussion

Nutrient uptake

The uptake of N was significantly increased with different irrigation levels of drip and surface methods during experimental period (Table 2) however; highest (130.86 kgha^{-1}) N uptake was recorded with T_5 treatment which was significantly higher over all other treatments and the lowest (47.60 kgha^{-1}) with T_1 treatment. Among drip irrigation system, T_6 recorded lower uptake of N which was similar with T_2 treatment. The maximum uptake of P was observed with the T_5 treatment followed by T_4, T_7 and T_8 treatments. Almost statistically similar P uptake was found in T_3, T_6 and T_2 treatments and least uptake of P was noted in T_1 treatment. There was observed significantly similar effect on K uptake of wheat. Maximum K uptake was attained by T_5 treatment; however all treatments were not showed statistically significant variation over different irrigation levels. This was also reported that due to alternate wetting and drying might have improved the soil aeration and thus root activity to improve the uptake of nutrients in drip irrigation system. Applying the nutrients through soil application resulted about 50% nitrogen loss due to volatilization and leaching. The results are in agreement with the findings Abdi *et al*. (2002) [1] and Gooding (2005) [3]. In the present study, higher uptake of total N, P and K by wheat crop in drip irrigation might be due to wheat produced more biomass with higher nutrient content at optimum soil moisture condition that was possible in drip irrigation method. Because, drip irrigation system is facilitates that maintained the soil moisture always at field capacity in vicinity of root surface. So, availability of nutrients was not limited throughout the crop growth stages under drip system leading to better uptake of nutrients. Similar results were also reported by Shaymaa *et al.* (2009) [9].

Nutrient use efficiency (NUE)

The NUE significantly varies by different irrigation regimes treatments has been depicted in (Table 3). The maximum NUE (23.30 kg grain/kg nutrient applied) was recorded in T_5 treatment i.e. irrigating the wheat with 100% CPE through drip system at two days interval and not varied with the result of T_4, T_7 and T_8 treatments. There was significantly no difference between T_6 and T_2 treatments for nutrients use efficiency. The lower efficiency of nutrients in the conventional surface method of irrigation might be due to uneven distribution and inadequate availability of nutrients and moisture in the root zone of the wheat crop may cause lower uptake of nutrients. In drip irrigation, adequate and suitable proportion of nutrients available in the soil solution under field capacity condition resulted in higher absorption of nutrients from the soil and eventually translocate into grain and straw. Therefore, higher nutrient use efficiency was observed in drip irrigation method. The results are in conformity with Goel *et al.,* (2005) [2].

Nitrogen Use Efficiency

The nitrogen use efficiency which represented as agronomic efficiency of nitrogen (AEN), uptake/recovery efficiency of nitrogen (REN) and physiological efficiency of nitrogen (PEN) was calculated and results are presented in (Table 4). The results on AEN are shows significant difference with drip irrigation levels. Significantly higher (19.58) AE of N was found in T_5 treatment and decreased in T_4 followed by T_8, T_7 and T_3 treatments. The T_2 treatment resulted in significantly lower AE of N but similar with T_6 treatment. Similar trend was observed in case of REN and PEN. Different treatments in drip irrigation showed statistically similar effects on REN except T_6 treatments showed lower REN and at par with T_2 treatment. PEN was resulted in no significant difference among the treatments. The higher PEN (37.85) was recorded in T_5 and lower (31.36) with T_6 treatment. This is the fact that contributed the higher efficiency of nitrogen at drip irrigation with alternate days wetting and drying.

Total Water Used

Total water use as irrigation water during the whole crop growing season ranged from 100.5 mm to 300 mm in different treatments is depicted in (Fig. 1). The total water used in T_2 plot with recommend irrigations at critical growth stages of crop was 300 mm. Among the drip irrigation treatments the minimum water use (100.15 mm) was recorded in treatment T_6 with drip irrigation at 50% CPE,4 days interval which was closely followed by 103.95 in T_3 treatment where the irrigation was given at 50% CPE, 2 days interval. Highest water use 207.90 mm was recorded with T_5 where the drip irrigation given at 100% CPE, 2 days interval. Total water used (irrigation as well as effective rain fall) was found to be highest 338.1mm in treatment T_2 with recommended irrigation and minimum (138.25mm)in T_6 with drip irrigation at 50% CPE,4 days interval. Irrigating the wheat crop with drip resulted in saving of water which ranged from 27.2% with T_5 to 59.1% with T_6 under different treatments. Irrigating the wheat crop at 100% CPE either on 2 or 4 days interval resulted in saving of similar quantity of water (27.2 and 29.4%).

Economic analysis

Data pertaining to added cost due to different drip irrigation treatments to the cost of cultivation without drip systems are presented in (Table 5). The total cost of cultivation for raising wheat crop ranged from ₹17100 in treatment T_1 and ₹20690 in T_2 i.e., recommended irrigation and fertilizer to highest ₹29100 in treatment T_5 with drip irrigation at 100% CPE on 2 days interval. The highest gross return ₹135642 was obtained from treatment T_5 closely followed by treatment T_4 (₹130098) with drip irrigation at 75% CPE, 2 days interval. Gross return in conventional sown wheat with recommended irrigation and fertilizers was ₹123103.The net return varied ₹50711in treatment T_1 to ₹106538 under treatment T_5 with 100% CPE, 2 days interval. The net return with treatment T_2 with recommended irrigation was ₹92404. Among the drip irrigation treatments the lowest net return ₹ 82608 were found in treatment T_6 with drip 50% CPE on 4 days interval. B: C ratio among the drip irrigated treatments ranged from 2.97 to 3.66.The B:C ratio of treatment T_2 where the recommended irrigation was given to wheat crop was

3.01.Highest B:C ratio was obtained with treatment T_5, where drip irrigation is given at 100 %CPE.Net return and B: C ratio had increased due to the high increase in grain yield which is the results of adequate water supply and nutrient availability through fertigation to the root zone area of the crop under drip irrigation system. The findings are in conformity with Ashoka *et al*., (2005).

Table 1: Fertigation schedule followed for wheat in drip irrigation system

DAS	Nitrogen @ 150 kg ha^{-1}			Phosphorus @ 60 kg ha^{-1}			Potassium @ 40 kg ha^{-1}		
	N %	N (kg ha^{-1})	Urea (kg ha^{-1})	P %	P (kg ha^{-1})	Phosphoric acid (kg ha^{-1})	K %	K (kg ha^{-1})	White potash (kg ha^{-1})
5-20	30.67	46	100	66.67	40	67			
21-60	69.33	104	225	33.33	20	33	62.5	25	41.67
61-100	-	-	-	-	-	-	37.5	15	25.00
Total	100	150	325	100	60	100	100	40	66.67

Table 2: Total Nutrient uptake (kg ha^{-1}) by wheat crop as influenced by different drip irrigation treatments

Treatments	Nitrogen	Phosphorus	Potassium
T_1	47.60	8.85	60.11
T_2	96.13	19.68	109.46
T_3	111.06	21.78	123.03
T_4	115.16	27.58	135.17
T_5	130.86	31.47	144.50
T_6	99.95	20.67	113.79
T_7	114.96	24.70	131.54
T_8	118.20	24.24	132.85
S.Em.±	2.81	0.76	3.98
CD (P=0.05)	8.32	2.25	11.80

Table 3: Nutrient use efficiency (NUE) of wheat as influenced by different drip irrigation treatments

Treatments	Grain yield (kg ha^{-1})	Total nutrient applied (kg ha^{-1})	NUE (kg grain/kg nutrient applied)
T_1	2887	-	-
T_2	4485	250	17.94
T_3	5180	250	20.72
T_4	5545	250	22.18
T_5	5825	250	23.30
T_6	4537	250	18.15
T_7	5370	250	21.48
T_8	5410	250	21.64
S. Em.±	164	-	0.66
CD (P=0.05)	487	-	1.95

Table 4: Nitrogen use efficiencies of wheat as influenced by different drip irrigation treatments

Treatments	Agronomic Efficiency	Recovery efficiency	Physiological efficiency
T_1	_	_	_
T_2	10.65	0.32	32.52
T_3	15.28	0.44	34.49
T_4	17.71	0.48	36.35
T_5	19.58	0.51	37.85
T_6	11.00	0.35	31.36
T_7	16.55	0.45	36.66
T_8	16.81	0.47	35.56
S.Em.±	1.11	0.02	1.70
CD (P=0.05)	3.33	0.05	NS

Table 5: Economic analysis of wheat as influenced by different drip irrigation treatments

Treatments	Cost of cultivation in ₹/ha	Gross return in ₹/ha	Net return in ₹/ha	B:C ratio
T_1	17100	67811	50711	2.96
T_2	20690	123103	92404	3.01
T_3	27804	122690	92218	3.32
T_4	28454	130098	98976	3.48
T_5	29104	135642	103870	3.57
T_6	27767	110375	79940	2.88
T_7	28392	126397	95337	3.35
T_8	29017	127331	95646	3.30

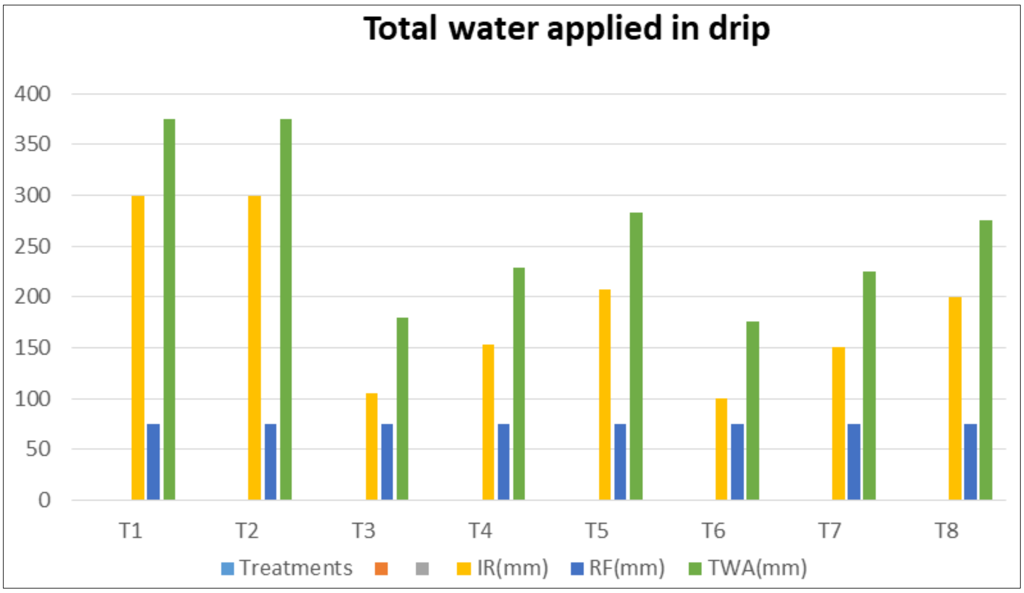

Fig 1: Total water applied in all the treatments.

Conclusion

In conclusion, the use of drip irrigation is seems to be a good option not only for water saving, higher yield but also improves the use efficiency of nutrients. The maximum efficiency of applied nutrient was obtained from water supply with 75% or 100% CPE through drip irrigation followed by fertigation at two days interval period. This system increased grain yield of wheat by 30% compared to farmers' practice. Hence, Scheduling of irrigation through drip system along with fertigation which enhances the nutrient uptake as well as total nutrient use efficiency may give an opportunity to harvest more yield per drop of water and nutrient by maintain the economic feasibility of farmers.

References

1. Abdi M, Mohamadi GN, Golchin A. The influence of foliar nutrition of urea and potassium chloride on grain yield, grain protein content, yield components and leaf relative water content of Sardari wheat under rainfed condition. J Agri. Sci. 2002; 8:29-38.
2. Goel AC, Vijaykumar, Dhindsa JPS. Feasibility of drip irrigation in sugarcane at Haryana, pp-4-9. Proc. Proc. Nation. Sem. Relevance of Micro irrigation in Sugarcane, VSI Pune, Maharashtra, India, 2005, 9-10.
3. Gooding MJ. Foliar urea fertilization and the management of yield and quality in wheat. Int. Fert. Soc. Proc, 2005, 573. http://www.fertiliser society.org/Proceedings/US/Prc573. HTM.
4. Li YR, Yong. The contents of ten nutritional elements in leaves of nine sugarcane genotypes. Sugar cane. 1993; 6:10-12.
5. Pawar DD, Dingre SK, Shinde MG, Kaore SV. Drip fertigation for Higher Crop Productivity. Research Book No. MPKV/ Res. Pub. No. 99/2013, MPKV, Rahuri-413-722, Maharashtra, India, 2013.
6. Patil GD, Yelwande AJ, Chaudhari RD. Nitrogen fertilization to sugarcane: Prospects and retrospect, J Maharashtra Agric. Univ. 2001; 26(1-3):156-158.
7. Rao PV, Rao PR, Ramanjanayulu AV. Micro irrigation technique for improved and sustainable crop production. Advance in Agro-technology (eds.), 2014.
8. Rodrigaez Hg, Sarkar NC, Ramajan Mayti R. Published by Pushpa Publishing House, Kolkata, India, 166-202.
9. Shaymaa I, Shedeed Zaghloul, Sahar M, Yassen AA. Effect of Method and Rate of Fertilizer Application under Drip Irrigation on Yield and Nutrient Uptake by Tomato. Ozean Journal of Applied Sciences. 2009; 2(2):139-147.
10. Veeranna HK, Abdul K, Sujith GM. Effect of fertigation and irrigation methods on yield, water and fertilizer use efficiencies in chilli (*Capsicum annum* L.). South Indian Hort. 2001; 49:1010-104.