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Effect of drip fertigation and its interval on growth, yield and economics of wheat (*Triticum aestivum* L.)

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Abstract
A field investigation entitled " Effect of drip fertigation and its interval on growth and yield of wheat (*Triticum aestivum* L.)" was carried out at Department of Agronomy Farm, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during the *Rabi* season of 2019-20. The experiment was laid out in Randomised Block Design with four replications and eight different irrigations and fertigation treatments imposed for wheat crop with an objective to study the effect of drip fertigation interval on growth, yield of wheat and economics of wheat crop through drip fertigation. The experimental site was established with inline drip irrigation system (16 mm) lateral laid out at 90 cm with 50 cm dripper spacing. Irrigation water was applied through drip irrigation system on every alternate day based on cumulative pan evaporation and surface irrigation water was applied at 1.0 IW/CPE ratio. Experiment results revealed that, the drip fertigation with 100 per cent recommended dose of N and K applied at seven days interval significantly improved the growth characters *viz*., plant height, number of tillers, number of leaves, leaf area index, total dry matter plant^{-1}, growth indices and yield contributing characters. Drip fertigation with 100 per cent recommended dose of N and K in seven days interval recorded higher grain yield of 5653 kg ha^{-1} which was at par with 100 per cent drip fertigation of recommended NK in fourteen days interval with grain yield of 5580 kg ha^{-1}. The highest gross monetary returns (₹133567 ha^{-1}) and net monetary returns (₹85999 ha^{-1}) and B: C ratio (2.81) was registered in the treatment receiving drip fertigation at 100 per cent NK ha^{-1} in seven days interval and found at par with drip fertigation with 100 per cent recommended dose of N and K in fourteen days interval than lower level and conventional method of fertilizer application in drip and furrow irrigation method.

Keywords: Drip, fertigation, economics, NPK, wheat

Introduction
Wheat (*Triticum aestivum* L.) is one of most important staple food crop of India grown in diverse agro-climatic condition. Wheat is a feeding bowl to mankind occupies a premier position of all the staple food grain crops. In India wheat is most important food after rice in term of both area and production which contributes 12% of the world wheat pool. In India during 2017-18 area under wheat cultivation was 309.60 Lakh hectare with annual production of 98.38 Lakh tons with an average productivity 3172 Kg ha^{-1}. In Maharashtra it occupies area of 12.72 Lakh hectare with production of 22.14 Lakh tons and average productivity is 1740 Kg ha^{-1}. (Ministry of Agriculture, New Delhi, Economics Times, Fourth Estimates 2017-18).
Area under wheat crop is irrigated by flood irrigation with very poor water use efficiency. India's water resources particularly in the context of agriculture, are facing extreme stress. Availability of irrigation water is the major limiting factor in improving wheat productivity. At present, more than 60 per cent of wheat area is under irrigated condition, of which about 50 per cent wheat crop is irrigated by only one or two irrigations (Chouhan and Yadav, 2012) [5]. With increasing demand of irrigation water, the irrigation efficiency and water use efficiency can be enhanced by replacing surface irrigation with micro irrigation i.e. drip methods especially in arid and semi-arid region. Drip irrigation can supply water both precisely and uniformly at high irrigation efficiency and judicious use of fertilizers. Recent technological development in drip and micro-irrigation methods have been accelerated the adoption of fertilizer application for a wider range of crops, including field crop like wheat with new concept i.e. fertigation. It also enables precise delivery of essential plant nutrients (fertigation) in small amounts, frequently (daily or weekly) according to crop developmental stages and physiological phases. Additional benefits of drip fertigation include energy and labour savings, no leaching, higher water productivity and nutrient use efficiency etc. Drip irrigation thus potentially increases yield, reducing subsurface drainage and providing better growth characters.

The introduction of simultaneous micro-irrigation and fertilizer application (fertigation) opens new possibilities for controlling water and nutrient supplies to crops besides maintaining the desired concentration and distribution of nutrients and water into the soil (Bar-Yosef, 1999) [1]. By introducing drip with fertigation, it is possible to increase the yield of crops by 3 times from the same quantity of water.

Indian agriculture generally depends on monsoon water but the monsoon rain is irregular and has inconsistency over a time and space. There is urgent need to give attention to the profitable use of resources like land and water with judicious use of fertilizers for the survival of ever-increasing population. The water and fertilizers are becoming costlier day by day and thus, there is a need of saving and efficient use of it without affecting the agricultural production and productivity. Drip irrigation and fertigation related research in wheat is very limited particularly the interval of fertilizer application through drip irrigation, optimal scheduling of drip irrigation and fertigation. This may further enhance the productivity of crop besides saving water. Minimizing the cost of irrigation and fertilizers, adoption of drip irrigation with fertigation is essential which will maximize the nutrient uptake, while using minimum amount of water and water soluble fertilizer. Hence, the present study was initiated to study the effect of drip fertigation and its interval on growth and yield of wheat (*Triticum aestivum* L.).

Materials and Methods

The field experiment was carried out at Agronomy Farm, Department of Agronomy, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during the *rabi* seasons of 2019-20. The topography of the field was fairly uniform and level. The soil was clay texture belonging to Vertisols. The experiment was laid out in randomised block design with four replications and eight different fertigation treatments imposed for wheat crop i.e. 100 per cent RDNK through soil application with surface irrigation (T_1), drip irrigation with 100 per cent RDNK through soil application(T_2), drip fertigation with 25 per cent RDNK in 7 days interval(T_3), drip fertigation with 25 per cent RDNK in 14 days interval (T_4), drip fertigation with 50 per cent RDNK in 7 days interval (T_5), drip fertigation with 50 per cent RDNK in 14 days interval (T_6), drip fertigation with 100 per cent RDNK in 7 days interval (T_7), drip fertigation with 100 per cent RDNK in 14 days interval (T_8). The experimental site was established with inline drip irrigation system (16 mm) lateral laid out at 90 cm with 50 cm dripper spacing. Irrigation water was applied through drip irrigation system on every alternate day based on cumulative pan evaporation and surface irrigation water was applied at 1.0 IW/CPE ratio at a depth of 6 cm. The irrigation water to be applied per plant was determined by the following formula. (Michael, 2008) [9].

$$V\ (lpd) = (ETo \times Kc \times A \times Wp) - (RE \times A)$$

Where,
V - Volume of water applied (litre/day/plant)
ETo - Reference evapotranspiration (mm/day)
Kc - Crop factor
A - Area under crop (m^2)
(Plant to plant spacing) × (Row to row spacing)
Wp – Wetted area fraction
RE – Effective rainfall in mm

The net depth of water to be applied in drip irrigation of alternate day was determined by the following formula. (Michael, 2008) [1].

$$D = (ETo \times Kc) - RE$$

Where,
D -Net depth of water to be required (mm)
ETO - Reference evapotranspiration (mm/day)
RE - Effective rainfall (mm)

The sources of nutrients were urea (46% N), single super phosphate (16% P_2O_5), and murate of potash (60% K_2O) for nitrogen, phosphorus and potash, respectively. The fertilizer was applied as per the treatments. The total dose of phosphorus was applied as basal dose in all the treatments and N and K was applied in weekly split dosage through drip up to 84 DAS. In treatment T_1 and T_2, 50% nitrogen and 100% dose of phosphorus and potassium was applied as a basal dose and remaining 50% nitrogen was applied as 25% + 25% at 21 and 45 days respectively after sowing manually. The fertilizer tank of 90 litre capacity was used to apply chemical fertilizer through the irrigation water. The variety of wheat crop PDKV-SARDAR (AKAW 4210-6) was sown on 19th November 2019 with recommended dose of fertilizers 100:50:50 kg NPK ha^{-1}.

Results and Discussion

Growth parameters of wheat crop

The data presented in Table 1 revealed that plant height, number of tillers m^{-2} at 80 DAS, number of leaves at 60 DAS and dry matter weight per plant was significantly influenced by different treatments. The highest value of plant height (97.90 cm), number of tillers m^{-2} (380), number of leaves (38.06) and dry matter weight per plant(20.82 g) were obtained under application of 100 per cent RDNK in 7 days interval (T_7) through fertigation and it was statistically at par with 100 per cent RDNK in 14 days interval (T_8) followed by 50% RDNK (T_5,T_6) through drip fertigation and 25% RDNK(T_3,T_4) in 7 and 14 days interval respectively. However lowest value for all the growth attributing characters were observed in surface irrigation with conventional method of fertilizer application (T_1) and 100% RDNK as basal with drip irrigation (T_2). The favourable increase in growth attributes in terms of plant height due to drip fertigation was earlier reported by Abdelarouf *et al*. (2013) [1], Bhowmik *et al*. (2018) [4] and Karangiya *et al*. (2019) [7].

Increase in the levels of N and K through fertigation increases the plant height, number of tillers, dry matter weight per plant and number of leaves at 60 DAS which might be due to enhanced availability and uptake of nutrients leading to enhanced photosynthesis, expansion of leaves and translocation of nutrients to the reproductive parts as compared to soil application method. Higher number of leaves per plant in fertigation of N and K splits might be due to higher uptake of nutrients and further vegetative growth of the wheat plant. Bhowmik *et al*. (2018) [4], Karangiya *et al*. (2019) [7] have reported the beneficial effect of higher level of RDNK fertigation on number of leaves and number of tillers in wheat crop which indicated that wheat required more nutrients for enhancing the yield attributes.

Table 1: Influence of different fertigation treatments on growth characters of wheat crop

Treatments	Plant height (cm)	Number of effective tillers m^{-2}	Number of leaves $plant^{-1}$	Dry matter $plant^{-1}$ (g)
T_1 - Surface irrigation + 100% RDF through soil application	64.46	279	21.32	9.74
T_2 - Drip irrigation + 100% RDF through soil application	74.92	311	26.12	12.70
T_3 - Drip fertigation with 25% RDNK (Once in 7 Days)+ 75% RDNK through soil application.	75.97	312	27.55	14.31
T_4 - Drip fertigation with 25% RDNK (Once in 14 Days)+75% RDNK through soil application	75.05	312	26.30	13.67
T_5 - Drip fertigation with 50% RDNK (Once in 7 Days) + 50% RDNK through soil application.	87.20	346	33.25	17.61
T_6 - Drip fertigation with 50% RDNK (Once in 14 Days)+ 50% RDNK through soil application.	86.44	344	32.33	16.91
T_7 - Drip fertigation with 100% RDNK (Once in 7 Days)	97.90	380	38.06	20.82
T_8 - Drip fertigation with 100% RDNK (Once in 14 Days)	97.53	377	37.90	20.07
S.E(m)±	3.47	10.39	1.53	0.82
C.D. at 5%	10.21	30.57	4.51	2.42

FI: Surface Irrigation DI: Drip Irrigation DF: Drip Fertigation RDNK: Recommended dose of N & K

Yield and yield attributes

Each higher fertigation level of recommended dose of N and K significantly increased the yield attributing characters like the length of spike (cm), number of grains per spike, grain weight per spike (g), grain weight per plant (g) and test weight (g) over its lower levels and soil application with drip & surface irrigation as indicated in Table 2. The grain yield and straw yield influenced significantly due to split application of recommended dose of nitrogen and potash through fertigation. Each higher level of RDNK through fertigation, at 100 per cent recommended dose of N and K in 7 days interval favourably increased these yield attributes than other lower level of fertigation and soil application method of applying fertilizers through surface and drip system. However, 100 per cent recommended dose of N and K in 14 days interval were equally effective in enhancing the all yield attributing characters. Lower values of all the yield attributing characters were observed in surface irrigation with 100 per cent recommended dose of fertilizer with soil application.

The substantial increase in the length of spike (cm), number of grains per spike, grain weight per spike (g) and grain weight per plant (g) due to higher levels of fertigation than lower level and conventional fertilizer application method was associated with the improvement in various growth attributes *viz*. plant height, number of effective tillers, functional leaves, leaf area, dry matter accumulation per plant and its subsequent translocations to sink. The cumulative effect of these finally improved the number of grains per plant and grain weight per plant depends on dry matter accumulation and its translocation to sink. The increase in more number of grains per plant and grain weight per plant under higher level of fertigation might be due to enhanced availability and uptake of nutrients to enhance photosynthesis, expansion of leaves and translocation of nutrients to reproductive parts as compared to lower rate of N and K given through fertigation and over conventional soil application of fertilizers. Similar advantage of higher level of fertigation of nutrients in improving the number of grains per plant and grain weight per plant were reported earlier by Saren and Jana (2001) [12] and Malve *et al*. (2014) [8].

Effect of higher levels of fertigation at 100 per cent RDNK in 7 and 14 days interval promoting the growth and yield parameters of the crop had positive impact on the final grain yield. The grain yield linearly increased with increasing levels of fertilizers applied through fertigation. Drip fertigation at 100 per cent RDNK in 7 days interval had recorded higher grain yield of 5653 kg ha^{-1} which was followed by 100 per cent drip fertigation of RDNK in 14 days interval with grain yield of 5580 kg ha^{-1} and drip fertigation with 50 per cent recommended dose of N and K in 7 and 14 days interval with grain yield of 5049, 4979 kg ha^{-1} respectively. Drip fertigation at 25 per cent RDNK ha^{-1} in 7 and 14 days interval recorded comparable yield with drip irrigation with 100 per cent recommended dose of N and K through fertigation when compared to conventional soil application of fertilizers. Drip fertigation at higher level of 100 per cent fertigation recorded higher harvest index and recorded an increased yield of 73.77 per cent over surface irrigation with 100 per cent recommended dose of NPK. Similar trend was noticed in respect of straw yield and biological yield. Increased nutrient availability and absorption by the crop at the optimum moisture supply coupled with frequent and higher nutrient supply by fertigation and consequent better formation and translocation of assimilates from source to sink might have increased grain yield under fertigation. The results are in conformity with the findings Pawar *et al*. (2013,) [10] Malve *et al*. (2014) [8], Bhowmik *et al*. (2018) [4].

Table 2: Yield attributing characters, Grain Yield and Straw Yield as influenced by different fertigation treatments

Treatments	No. of grains per spike	Grain wt. per plant (g)	Test weight (g)	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})
T_1 - Surface irrigation + 100% RDF through soil application	32.60	5.40	39.88	3253	5328
T_2 - Drip irrigation + 100% RDF through soil application	35.88	7.98	40.69	4328	6432
T_3 - Drip fertigation with 25% RDNK (Once in 7 Days)+ 75% RDNK through soil application.	36.22	8.33	40.86	4404	6491
T_4 - Drip fertigation with 25% RDNK (Once in 14 Days)+75% RDNK through soil application	36.10	8.20	40.72	4377	6460
T_5 - Drip fertigation with 50% RDNK (Once in 7 Days) + 50% RDNK through soil application.	40.09	10.08	41.16	5049	7409
T_6 - Drip fertigation with 50% RDNK (Once in 14 Days)+ 50% RDNK through soil application.	39.83	9.88	40.92	4979	7326
T_7 - Drip fertigation with 100% RDNK (Once in 7 Days)	44.00	11.85	41.82	5653	8249
T_8 - Drip fertigation with 100% RDNK (Once in 14 Days)	43.88	11.70	41.48	5580	8174
S.E(m)±	1.04	0.46	1.24	175	257
C.D. at 5%	3.06	1.37	NS	514	757

Economics studies

Highest gross monetary returns (₹133567 ha^{-1}) and net monetary returns (₹85999 ha^{-1}) and B:C ratio (2.81) were obtained in the treatment receiving drip fertigation at 100 per cent RDNK ha^{-1} in 7 days interval and found at par with drip fertigation with 100 per cent recommended dose of N and K in 14 days interval. The significantly lowest GMR, NMR and B:C ratio was registered in the treatment where fertilizer was applied through conventional method (Table 3). Similar results were reported by Praharaj and Kumar (2012) [11], Kakade *et al*. (2017) [6], Karangiya *et al*. (2019) [7].

Table 3: Gross monetary returns, Net monetary returns, and B:C ratio as influenced by different fertigation treatments

Treatments	GMR Rs/ha	COC Rs/ha	NMR Rs/ha	B:C Ratio
T_1 - Surface irrigation + 100% RDF through soil application	78603	38971	39632	2.02
T_2 - Drip irrigation + 100% RDF through soil application	102615	49568	53047	2.07
T_3 - Drip fertigation with 25% RDNK (Once in 7 Days)+ 75% RDNK through soil application.	104249	49068	55181	2.12
T_4 - Drip fertigation with 25% RDNK (Once in 14 Days)+75% RDNK through soil application	103637	49068	54569	2.11
T_5 - Drip fertigation with 50% RDNK (Once in 7 Days) + 50% RDNK through soil application.	119411	48568	70843	2.46
T_6 - Drip fertigation with 50% RDNK (Once in 14 Days)+ 50% RDNK through soil application.	117813	48568	69245	2.43
T_7 - Drip fertigation with 100% RDNK (Once in 7 Days)	133567	47568	85999	2.81
T_8 - Drip fertigation with 100% RDNK (Once in 14 Days)	131942	47568	84374	2.77
S.E(m)±	3378	-	3378	-
C.D. at 5%	9934	-	9934	-

Conclusions

It could be concluded from the study that drip fertigation with 100% recommended dose of N and K in 7 days interval found to be best treatment which is at par with 100% RDNK in 14 days interval for improving growth attributes, maximizing the grain yield and beneficial in increasing the productivity and economic returns in wheat crop.

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