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Assessing Impact of Drip Irrigation and Nitrogen Fertigation Scheduling on Physiological Traits of Winter Wheat (*Triticum aestivum* L.)

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Abstract In order to study physiological traits of winter wheat (*Triticum aestivum* L.) at different levels of drip irrigation and nitrogen fertigation scheduling, a field experiment was conducted during 2012-13 and 2013-14 at Jain Hi-Tech Agri. Institute, Jain Irrigation Systems Ltd., Jalgaon located at western scarcity zone of Maharashtra, India. Physiological traits were measured like LAI, LAD, CGR, RGR and BMD. The results revealed that drip irrigation at 1.0 Epan gave significantly superior performance of all physiological traits but it was on par with 1.2 Epan and significantly superior over 0.6, 0.8 Epan and surface check basin irrigation at 1.0 IW : CPE ratio. Similarly, fertigation of 120 kg N ha^{-1} significantly improved all physiological traits over lower nitrogen levels in both the years. However, application higher dose of nitrogen (N_{160}) did not showed significant response over N_{120}. Several relationship viz., CGR vs LAI, CGR vs LAD, LAD vs LAI were analyzed at different irrigation and nitrogen fertigation scheduling and regressions accounted 99.0%, 98.9%, 99.8% and 96.5%, 98.9%, 99.2% respectively.

Keywords Drip irrigation, Fertigation, Physiological traits, Regression.

Introduction

Wheat is considered as 2[nd] most important staple crop of India after rice which covers area of 28.9 million hector with production of 88.4 million tons. Out of total cultivated wheat area in India, 92% area under irrigation. Productivity of wheat is highly influenced by proper irrigation scheduling and fertilization. Now days due to erratic behavior of monsoon and uncontrolled exploitation of ground watercause water scarcity [1]. The scarce water resources in the country necessitates its economic use which will be possible only by adopting advanced technology of irrigation like micro irrigation. Micro-irrigation is a high frequency irrigation method of supplying water directly to the plant root zone. Adoption of micro-irrigation might help in raising the irrigated area, productivity of crops and water-use efficiency. However, the coverage was primarily restricted to horticultural crops.

Among the chemical fertilizer, nitrogen is also considered one of the most important factors affecting crop morphology, physiological traits and grain yield [2]. Application of fertilizer through irrigation systems i.e. Fertigation which is component of drip irrigation systems through which nutrients were ap-

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plied directly into the root zone of plant along with water. Identification of growth physiological traits is analysis of factors affecting final yield of crop. In this regard leaf area index (LAI), leaf area duration (LAD), crop growth rate (CGR), relative growth rate (RGR) and biomass duration (BMD) should be measured in periodic intervals during the growing season for evaluation of plant productivity [3].

In the present water crises scenario, research works on drip irrigation and fertigation scheduling on row crops like wheat is very meager therefore the main aim of experiment to study to assess the impact drip irrigation and nitrogen fertigation scheduling on physiological traits of winter wheat.

Materials and Methods

A Field experiment was carried out during winter (*rabi*) season of 2012-13 and 2013-14 at Jain Hi-Tech Agri. Institute, Jalgaon, Maharashtra. The site is geographically situated at 21°01´52´´ N-Latitude, 75°56´38´´ E-Longitude and at an altitude of 292 m above mean sea level. The soil was sandy clay loam in texture, neutral in reaction with S_1 salinity class. The soil was low in nitrogen, high in phosphorus and medium in potassium. The soil moisture retention capacity at field capacity and at permanent wilting point of the experimental site was 22.40% and 10.30% (0—60 cm) estimated by the standard procedures.

LOK-1 wheat variety @ 125 kg ha^{-1} was sown on 6th November in 2012-13 and 1st November in 2013-14 and the recommended dose of fertilizers was 120 : 60 : 60 NPK kg ha^{-1}. The experiment was laid out in a split plot design with twenty treatment combinations and replicated four times. The main treatment comprised five irrigation levels involving four irrigation through drip (DI–0.6, 0.8, 1.0, 1.2 Epan and one control [SI-surface check basin irrigation at 1 IW : CPE ratio] as main treatments along with four N-fertigation schedule viz., control, 80, 120 and 160 kg ha^{-1} through drip. Drip irrigation was scheduled once in two days and N-fertigation scheduled once in a week for up to 65 days. Inline dripper line laid out on the ground surface along the crop rows at 0.90 m apart with emitters spaced at 0.30 m apart delivering 4 L ha^{-1}. Gross plot size was 9.0 m × 3.6 m and net plot size was 8.0 m × 2.7 m.

Physiological traits

Leaf area index (*LAI*)

Leaves are the primary photosynthetic organs of the plant ; it is desirable to express plant growth on leaf area (one side only) basis. The leaf area index was calculated by dividing the total leaf area with the corresponding ground area and measured at 30, 60 DAS and at harvest with LI 3100 Leaf Area Meter (LI-COR, INC.Linocoln, Nebraska, USA).

$$\text{LAI} = \frac{\text{Total leaf area}}{\text{Unit ground area}}$$

Leaf area duration (*LAD*)

Leaf area duration (LAD) expresses the magnitude and persistence of leaf area or leafiness during the period of crop growth. If leaf area is plotted against time, it produces a function that indicates the assimilatory capacity of a crop during the period in question. LAD based on leaf area of individual plants from successive harvests was calculated as:

$$\text{LAD} = \frac{(LA_2 + LA_1)\ (t_2 - t_1)}{2}$$

Where, LA_2 and LA_1 are leaf areas in M^2 obtained at times t_2 and t_1, respectively. LAD represents mean LAD expressed in dm^2 days.

Crop growth rate (*CGR*)

The growth rate of a plant or crop growth (CGR) of a unit area of canopy cover at any instant time (t) is defined as "the increase of plant material per unit of time" and is mathematically given as:

$$\text{CGR} = \frac{(W_2 - W_1)}{(t_2 - t_1)} \times \frac{1}{P}$$

Where, W_2 and W_1 are the values of dry weight of plant (g) harvested from equal but separate areas of ground, (P) at times t_2 and t_1 in days, respectively., and CGR is the mean crop growth rate expressed in g m^{-2} day $^{-1}$.

Relative growth rate (*RGR*)

The relative growth rate (RGR) of a plant at time instant (t) is defined as the increase of plant material per unit of material initially present per unit of time and is mathematically expressed as:

$$RGR = \frac{(\ln W_2 - \ln W_1)}{(t_2 - t_1)}$$

Where, W_2 and W_1 are dry weights (g) at times t_2 and t_1 in days, respectively and RGR represents the relative growth rate expressed in g g^{-1} day^{-1} ; In is natuural logarithm.

Biomass duration (*BMD*)

Biomass duration is analogous to LAD. If the area under time curve for biomass (dry matter) production is calculate as explained for LAD, the value for biomass persistence with time is obtained.

$$BMD = \frac{(W_2 + W_1)\ (t_2 - t_1)}{2}$$

Where, W_2 and W_1 are dry weight of a plant (g) at time t_2 and t_1, respectively and BMD is mean biomass duration in g days.

Statistical analysis

The data obtained on the different physiological traits were analyzed statistically by the method of analysis of variance as per the standard procedure outlined for split plot design. Statistical significance was tested by *F*–value at 0.05 level of probability and critical difference was worked out where ever the effects were significant.

Results and Discussion

Leaf area index (LAI)

Drip irrigations at each higher level of evaporation replenishment from 0.6 to 1.2 Epan produced significantly higher leaf area index over its lower irrigation level and surface irrigation (IW : CPE = 1) except that the difference between 1.0 and 1.2 Epan was statistically not significant at all the growth stages in both the years. Crop grown at 1.0 and 1.2 Epan drip treatments maintained with higher soil water availability making the plant put rapid growth intense of leaf, stem and enhancing number of tillers, which in turn helped the plants to put forth more canopy cover i.e., LAI [4]. High yield potential of cultivars is determined by both the efficiency of photosynthesis source and the sink capacity of grains to receiving leaf photosynthesis. Further variation in leaf area index with irrigation is well documented [5].

In case of nitrogen levels (2012-13 and 2013-14) at all the growth stages, each higher level of N application significantly increased the leaf area index over its lower level from 0 kg N ha^{-1} to 160 N ha^{-1}, except that the difference in LAI between N_{120} (120 kg N ha^{-1}) and N_{160} (160 kg N ha^{-1}) was statistically not significant (Fig. 1). The mean percentage increase of LAI at harvest under N_{120} was 102.9 and 23.9% over N_0 and N_{80}, respectively. Several researchers have also observed similar results of increased LAI at the higher level of nitrogen application in wheat crop [6]. Nitrogen supply to the plant influences the amount of protein, protoplasm and chlorophyll formed which in turn to influences cell size and leaf area, and photosynthetic activity.

Leaf area duration (dm^2 days)

Each higher level of drip irrigation from 0.6 to 1.2 Epan markedly increased the LAD over its lower levels at all crop growth stages in both the years of 2012-13 and 2013-14. However, the increase was at a diminishing rate from 1.0 to 1.2 Epan. The variation in leaf area duration could be traced to similar variation noticed in LAI. In case of nitrogen levels, mean LAD as influenced by different nitrogen levels is presented in Fig. 1. In case of nitrogen levels, each higher level

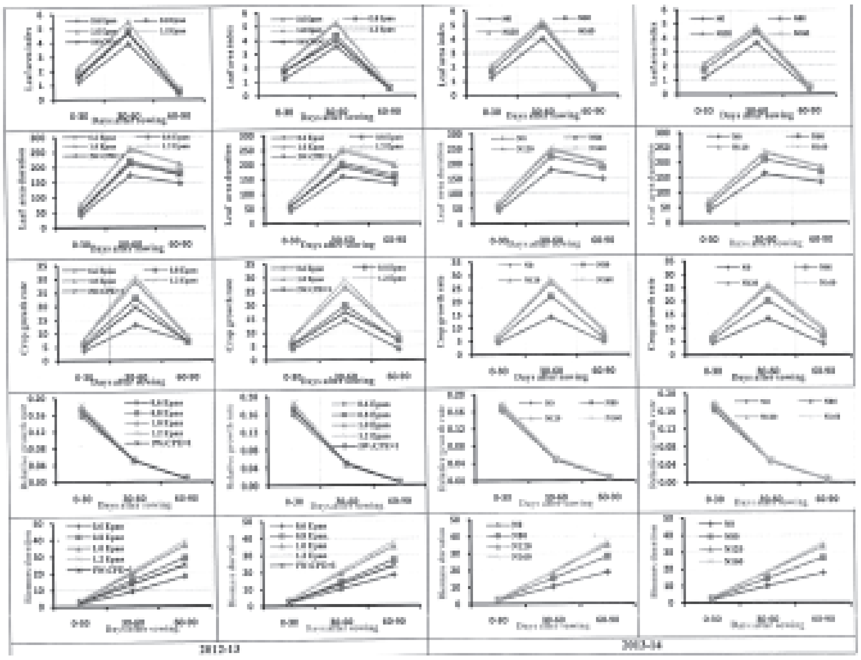

Fig. 1. Leaf area duration, crop growth rate, relative growth rates and biomass duration of wheat as influenced by different irrigation and nitrogen levels.

of nitrogen markedly increased the LAD over its lower level from 0 to 160 kg N ha^{-1} at all the crop growth stages in both the years. In the present study a positive correlation was found between LAD and LAI (Fig. 2 and 3). Determination coefficient (R^2) was calculated as 99.88% and 99.28% at different irrigation and nitrogen fertigation scheduling, which showed a linear increase in the LAD with the corresponding increase in LAI.

Crop growth rate (CGR)
(g m^{-2} day^{-1})

Increased in drip irrigation regime from 0.6 to 1.2 Epan improved the crop growth rates markedly at all the growth stages in both the years of 2012-13 and 2013-14, respectively. Reduction in CGR's at lower evaporation replenishment (0.6 and 0.8 Epan) treatments can be attributed to decrease in total photosynthesis rate consequently the reduction in leaf area index and dry matter production owing to water stress conditions. Similarly, each higher level of nitrogen from 0 kg N ha^{-1} to 160 kg N ha^{-1} has markedly improved the CGRs over its lower level at all the crop growth stages of wheat in both the years. However, the rate of increase in CGRs diminished at higher N levels i.e., between N_{120} and N_{160} (Fig. 1). CGR of wheat crop has a significant relation with nitrogen as in most plants nitrogen was essential for healthy and vigorus growth which in turn help the plants to absorb water and light more efficiently resulted in taller plants, higher LAI, dry matter, more number of tillers and higher CGR [6]. A positive correlation existed between CGR vs LAI and CGR vs LAD and the regressions accounted for 99.07% and 98.99% variability in CGR at different irrigation scheduling and 96.56% and 98.97% at varying nitrogen fertigation levels, respectively (Fig. 2 and 3).

Mean relative growth rate (RGR)
(g g^{-1} day^{-1})

Increasing drip irrigation levels from 0.6 to 1.2 Epan markedly increased the RGR over its lower levels but

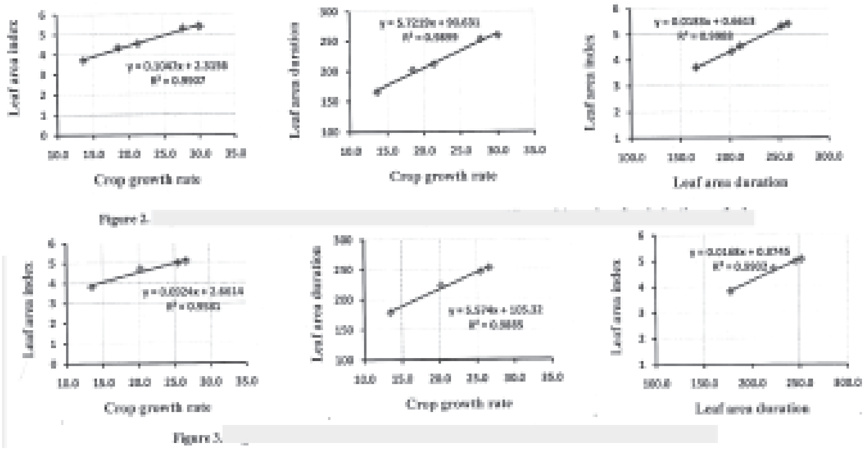

Fig. 2. Regression of CGR vs LAI, CGR vs LAD and LAD vs LAI at different drip and surface irrigation method. **Fig. 3.** Regression of CGR vs LAI, CGR vs LAD and LAD vs LAI at different nitrogen levels.

significant response was recorded up to 1.2 Epanin both the years of study. Similarly, unit increase in nitrogen levels from 0 kg N ha^{-1} to 160 kg N ha^{-1} markedly improved the RGR over its lower level at all the crop growth stages of wheat in both years. However, the rate of increase in RGR diminished at higher N levels i.e., between N_{120} and N_{160} (Fig. 1). Similar observations were made by [7] in rice. The decreases in RGR at deficit irrigation and nitrogen levels is being attributed for several reasons viz., non-photosynthetic biomass (roots and stems) increases, the top leaves of a plant begin to shade lower leaves and soil nutrients can become limiting [8].

Mean biomass duration (BMD)
(g days^{-1})

Each higher level of drip irrigation from 0.6 to 1.2 Epan markedly increased the BMD over its lower levels at all crop growth stages in both the years. However, the increase was at a diminishing rate from 1.0 to 1.2 Epan. The variation in biomass duration could be traced to similar variation in dry matter production. Similarly, each unit increase in nitrogen from 0 kg N ha^{-1} to 160 kg N ha^{-1} markedly improved the BMD over its lower level at all the crop growth stages of wheat in both the years. However, the rate of increase in BMD diminished at higher N levels i.e., between N_{120} and N_{160} (Fig. 1).

Conclusion

Present investigation indicates that drip irrigation at 1.0 Epan gave superior performance of all physiological traits i.e. LAI, LAD, CGR, RGR and BMD. Among the N-fertigation, each higher level of nitrogen levels up to 120 kg N ha^{-1} (N_{120}) significantly improved the performance of wheat over lower level. We recommend drip irrigation along with nitrogen fertigation for wheat grown in water scare regions in India.

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