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Influence of Water and Nitrogen Supply on Leaf Growth and Development at Different Nodal Position in Ryegrass (*Lolium perenne* L.)

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Abstract
Grass vegetative growth is highly dependent on water and nitrogen IN) availability. The objective of the experiment was to examine the effect of partial drought under two different N levels on leaf growth and development at various nodal position of the plant. Irrigated versus non irrigated treatment significantly influenced leaf area development of all leaves developed on the different nodal position of ryegrass plant. The same effect of the water treatment was observed on leaf length and width. However, the leaf width was not as much influenced as the leaf length. The change in leaf length was found the major cause in change of leaf area development. The leaf masses are also influenced in a similar way as the leaf width by altering water supply to the crop. High N supply also contributed positively in the development of leaf area. This increase in the leaf area of the different leaves appeared on various nodes of a plant was due to the N effect on individual leaf length rather than leaf width. Leaves on the nodal position 3 were the greatest in size and weight and showed the maximum differences due to different water and N supplies. The mean leaf area, length, width and mass was increased from nod No 1 to 3 and thereafter, decreased. Nevertheless, effect of the treatments supply was almost the same with respect to their sizes.

Introduction
Ryegrass is one of the most important forage grown in many countries of the world. Its forage is nutritious and highly digestible. It is widely grown both on arable lands and on rangeland. The growth and biomass distribution of grasses is dependent primarily on management and water status (Paez and Gonzalez, 1995). Nevertheless, soil N is an important factor of grass sward development. The N availability to grass enhanced plant vegetative growth (Karrou and Maranvilla, 1994) due to increase in leaf area and leaf photosynthesis. In fact, drought stress negatively influenced plant growth because water is essential factor of life preservation and production of plant. Under severe drought condition, plant is unable to survive. However, a stressed plant declines rate of photosynthesis by stomata closure due to the tourgur pressure reduction in guard cells and also by the activation of photosynthetic system in the chlorophyll. Grass leaf, the most important forage component, is contributing in herbage quantity and quality. In terms of quantity, it has been reported that dry matter production is linearly related with solar radiation interception (Monteith, 1981) and the amount of crop evapo-transpiration (Riveros *et al.*, 1994). While both light interception and evapotranspiration are primarily the cause of leaf area exposed to solar light. In terms of quality, a grass leaf has 2-3 times greater N concentration than stem and is highly digestible than any other plant organs (Buxton, 1996). The leaf area expansion results of cell wall expansion (Nelson, 1996). For both cell expansion and cell multiplication which are the sources of leaf growth and development, water as well as N is essential. Therefore, it might be interested to study the effect of drought and N supply on leaf growth and development at various nodal position of the plant.

Materials and Methods
English-Ryegrass was planted on 21.10.1995 in randomised complete block design having three replications under split plot arrangement. Water supply was in the main plots, whereas, nitrogen levels in the sub-plots size (8m x 6m), Field was fertilised at sowing time with 120 kg P ha^{-1} and 50 kg K ha^{-1}. N was supplied at the rate 50 and 100 kg ha^{-1} as N1 and N2 treatments.
The impact of water and nitrogen treatments were studied on the leaf growth characters of ryegrass (leaf blade length, width, area and weight) during the second regrowth phase (i.e. 25 days after defoliation). Five plants were uprooted from the 3 replicates since April 3 to April 25 at every third day, by selecting 10 healthy tillers from the sample. All leaves from the selected ten tillers were detached and the basal leaf on the tillers was numbered as the first leaf followed by increasing order. All leaves on nodal position 1 to 5 were passed through an area meter (LI-COR, LI-3000A) and their area, length and average width were measured. Thereafter, leaves were ovens dried at 60°C for about 48 hours for leaf dry mass determination. Gypsum blocks were fixed at 30 cm depth in the sub plots for soil moisture study. The average moisture content observed in plots for W_1 and W_2 were 11.78 percent and 84.54 percent respectively. Statistical analysis was performed using Statistical Analysis System (SAS) programme package (SAS Institute, Raleigh, N.C). Tukey test for mean separation was used to determine the significance of treatment differences.

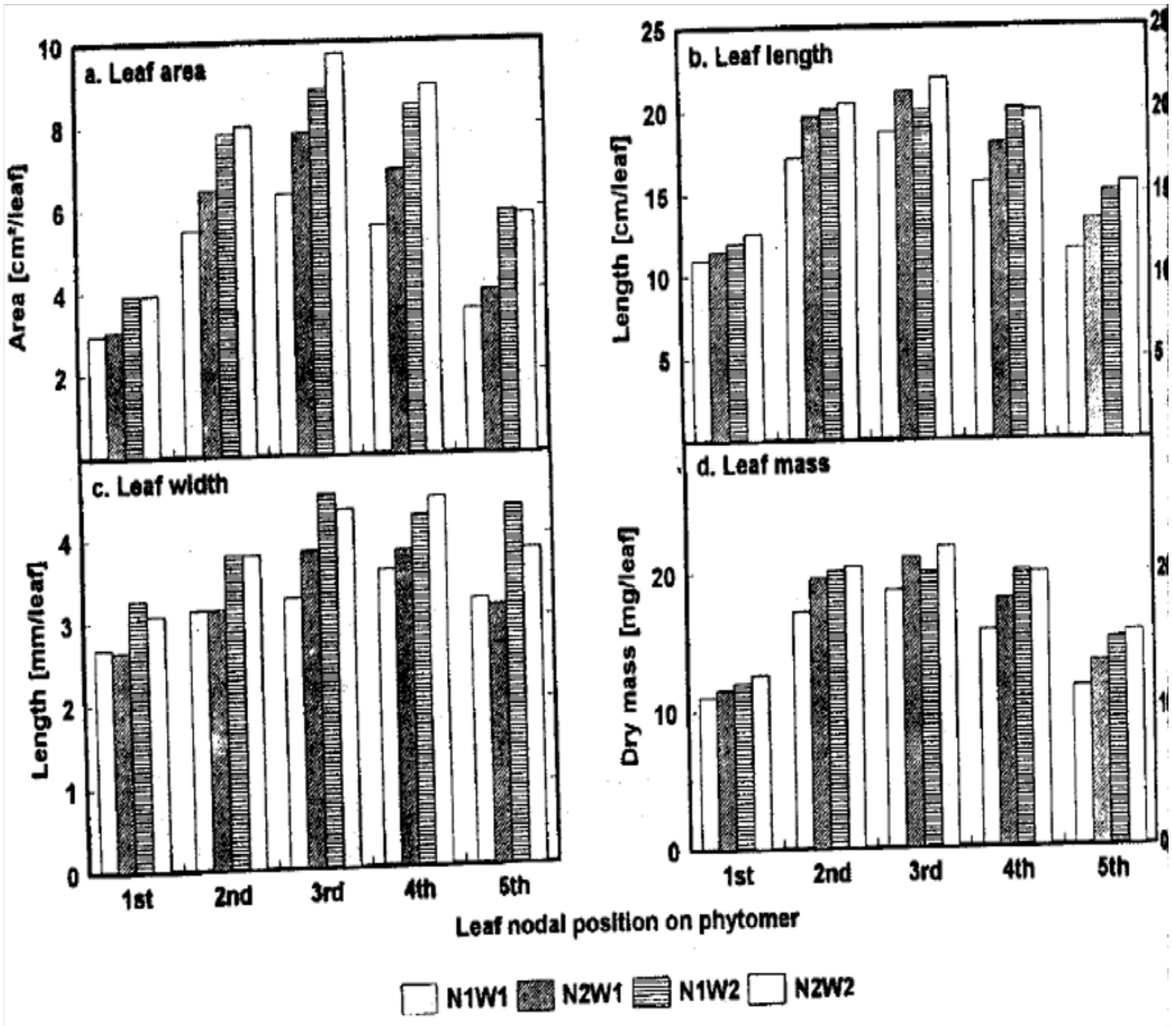

Fig. 1: Interactive effect of water regimes and N levels on ryegrass leaf (a) area, (b) length, (c) width and (d) mass initiated different nodal positions during the regrowth phase. The 1st nodal position here is the basal node having leaf during sampling

Results

Ryegrass leaf parameters (i.e. area, length, width and mass) as influenced by the respective levels of water and N regimes are presented in Fig. 1. Well-irrigated plots significantly ($p<0.05$) exceeded leaf blade area (39.9%), length (12.7%), width (22.4%) and weight (11.0%) than the non-irrigated treatment significantly ($p<0.05$) positive effect of the high N fertilization was also observed on the leaf blade area (9.9%), length (7.9%) and weight (7.2%). However, the levels of N-fertilizer application did not significantly influence leaf blade width.

Nodal position of tillers also influenced leaf area, lenght, width as well as dry mass under different water and combinations. The leaf that appeared on the nodal position 3 was significantly greater in size and mass than the other leaves initiated above or below that node on the tiller. The greater size and mass of the third leaf was common under all treatment combinations. This growth pattern was a mimicked by the leaves appeared at node 4 for width, area and mass except the leaf length. The basal leaf appeared node 1 showed significantly ($p<0.05$) lower values of leaf area, length, width as well as of dry mass than the other leaves initiated on that tiller.

Leaf area of at nodal position 1, 2 and 5 was adversely affected by limited water supply. This reduction in leaf area was associated with drought effects on leaf width rather than on leaf length. N did riot play any significant role for leaf development at that nodal position for leaf development. Leaves of the nodal positions 3 and 4 were drastically affected in length and width under drought and low N rates and hence resulted in a significant ($p<0.05$) decrease in leaf area. Plants under W_1 and N_1 had decreased area, length, width and dry mass at all nodes of the tiller.

Discussion

Leaf area development is one among the important characters of plant growth. The leaf growth is highly influenced by the shortages of any production factor and hence resulted in low herbage DM. This is due to the reason that the rate of carbon exchange becomes limited and hence the net photosynthesis reduced. Moreover, the crap radiation interception efficiency decreased due to smaller leaf area exposed to radiation. This reflected crop growth rate and biomass production (Parry *et al.*, 1992). Leaf growth is the important factor in all crops but particularly in forage crops (Nelson, 1996) because of its higher percentage of nutrients contribution to animal feed (Buxton, 1996). In this experiment, ryegrass leaf growth and development was strongly influenced by water as well as N supply rates. A number of experiments reported that water shortage (Passioura, 1994) and nutrient deficiency (Harper, 1994) adversely affect leaf growth and development of the grasses. This supported results of this experiment. Water effect was found stronger than N effect, because final epidermal cell length is generally similar for a genotype over a range of environments (Volenec and Nelson, 1981, 1983) and N concentration (Gastal and Nelson, 1994) but not for water stress (Nelson, 1996). Cell expansion and multiplication is due to turgor and properties of the expending cell wall (Cosgrove, 1986).

Under sufficient water supply, cell multiplication and division was high and hence this yielded greater leaf area to all leaves produced on a tiller regardless its nodal position. In contrast, the N fertilization affected leaf area development only for the leaf appeared at nodal position 2, 3 and 4. At first leaf developmental stage the source and sink might be balanced for plant nutritional requirements but with the development of further leaves on tillers adversely affected its leaf size and area which might be due to limited supply of the sources (N and water in this case). The effect of the treatments was quite visible on leaf length rather than its width. A further leaf development on a tiller, its source and sink supply was not in balance and hence the treatments effect was found stronger on leaf length rather than width which resulted a strong effect on leaf area development. A non-significant difference of the top leaf appeared at node 5 could be due to the N recycling within the plant's tillers (Hirose and Werger, 1987; Feller, 1990). The N treatments had a stronger effect on leaf width rather than on leaf length. Whereas, the treatments drought stress negatively influenced both leaf length as well as width. Moreover, treatments impact was common for all leaves appeared at any nodal position of the tillers.

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