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PJBS

ISSN 1028-8880

Pakistan Journal of Biological Sciences

ANSInet

Asian Network for Scientific Information

308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Pakistan Journal of Biological Sciences 3 (12): 2072-2074, 2000

Yield Performance in Three Commercial Wheat Varieties due to Flag Leaf Area

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Abstract: The major objective of planting wheat in Pakistan is to get grains and then straw. Flag leaf contribution is reported over 40% in grain development. However, the greater flag leaf area development is not the sole reason to reflect greater mass for a variety. Our study showed that duration of the flag leaf area is also equally responsible to reflect maximum out put from a variety. To study variation in the grain yield of wheat varieties (Khyber 87, Suleman 96 and Nowshera, 96), the experiment was conducted at the Agronomy research farm of the NWFP Agricultural University, Peshawar during 1998-99. Sowing was done on November 22, in rows 30 cm apart using three replications. Data was recorded on weekly basis for dry matter increment, leaf tiller number, leaf stem mass, flag leaf area, biomass and grain yield. Significant ($p<0.05$) differences were observed among the three varieties in yielding leaf and stem masses per tiller, flag leaf area, spike weight, grain weight and biomass as well as grain yield. However, leaf and tiller per plant and developmental rate per week of the three varieties were non-significant. The variation in grain weight per module was due to variation in flag leaf area and its duration. Nowshera 96 had prolonged anthesis duration and hence reflected higher grain weight as well as yield. Duration in flag leaf area rather than development made significant differences in yield of the three varieties.

Key words: Wheat varieties, growth, flag leaf area, yield and yield components

Introduction

The increase in plant mass due to assimilation i.e. production rate expresses the increase in dry matter per unit time during growth which is determined by periodic harvesting. The unit leaf area is the basis of measuring productivity in different plant species and varieties during their growth and development under a particular environmental condition prevailing over the season (Walter, 1995). Considering all growth factors constant, variation in yield in different varieties of wheat could be idiosyncrasy to the leaves developmental rate of the individual variety. It is due to that dry matter development is product of the solar radiation absorption, the rate of transpiration, and simultaneously the amount of CO_2 fixation. Leaf area increase contributes for canopy development. As the leaf area increases, a greater photosynthetically active surface area becomes available and it would therefore be expected that the production rate would be greater the higher the leaf area index (LAI). At close canopy, after attaining the critical LAI, crop growth rate is generally constant. Here the senescence becomes active. During senescence, the older leaves exported nitrogen and assimilates to the now growing regions. With plant age, the rate of partitioning varies among the plant organs. At spike development, flag leaf is the major contributor of the seed yield (Dickson, 1991; Kozlowski, 1992).

Nevertheless, production of tiller number per plant also depends on leaf number per main tiller, which also contributes to final grain yield (Campbell and Davidson, 1979). Assimilates partitioning during the reproductive stage is important for the seed development and producing grain number and weight of the corresponding spike. The present study was aimed to investigate that differences in yield of the different varieties could be due to differences in growth rate or differences in flag leaf area and duration.

Methods and Materials

Location and treatments: Three improved wheat varieties were selected to study the effect of flag leaf area and duration in producing grain yield of wheat. The experiment was carried out at Agronomy Research Farm of the NWFP Agricultural University, Peshawar during 1998-99. Planting was done on November 22, 1998. Presently the Khyber-87, Nowshera-96, and Suleman-96 are improved varieties and are commercially cultivated on large scale in the province. These three varieties were tested for yield differences due to the flag leaf area development and duration. The experiment was designed in randomized complete blocks having three replications. All the three varieties were randomly assigned to each individual experimental units of size 5x6 m^2.

Cultural Practices: The seedbed was prepared by 3 plowing each of about 0.25 m of depth and subsequently followed by a set of cross planking. Before sowing, a basal dose of 60-7000 kg ha^{-1} N-P-K was applied. Sowing was done in rows 30 cm apart in East-West direction. Two weeks after emergence, plants of the central rows *were* thinned manually maintaining plant to plant distance of 10 cm within the rows. Three manual weeding scheduled on 45, 60 and 90 days after sowing (DAS) were done to control weeds during the vegetative growth. The crop was irrigated four times during the season as per water demand of the crop. The second dose of N at the rate of 60 kg ha^{-1} was supplied on 107 DAS.

Observations: To study the, above ground dry matter, three uniform plants were selected from each experimental unit at weekly intervals. The plants were washed thoroughly to evade extra clay form basal portion. All material was dried for thirty hours at 60°C in oven. The dried material was weighed for dry matter estimation. On 108 DAS, three representative plants were obtained to determine tiller and leaf number per plant. The same material was subsequently used to estimate the leaf/stem ratio. The dry matter partitioning i.e. distributing plants into fractions of leaf, stem including sheath and spikes was recorded at anthesis stage of the plant growth. The flag leaf area of the ninety selected tillers was measured using leaf area measuring machine (L1-3000 A -L1-COR, USA). The final grain yield was determined by harvesting 2 meters long one pair of the central rows in each treatment. All data were statistically analyzed using SAS statistical package to evaluate the treatment comparison and means were tested using LSD ($p\leq0.05$).

Results

Dry matter accumulation during the vegetative growth revealed a non-significant growth rate (g/plant) for the varieties (Fig. 1). Using modified Richard's function for smoothing the curve for dry matter versus days after sowing, it was confirmed that the growth trend of the varieties was uniform during the experiment. A strong positive correlation (r^2 = 0.98) was found between plant dry matter production and days after sowing. The performance of tiller and leaf number per plant was also not influenced statistically due to varieties (Table 1).

Table 1: Data regarding wheat leaf and tiller number, leaf and stem masses and leaf to stem ratio observed in three recommended wheat varieties at the NWFP Agriculture University in 1999

Varieties	Tiller number per plant	Leaf number per plant	leaf mass g/plant	Stem mass g/plant	Leaf to stem ratio
Nowshera-96	10.11a	37.33a	4.67a	15.67h	0.30a
Suleman-96	10.55a	38.33a	3.00c	19.00a	0.16b
Khyber 87	09. 55a	36.00a	3.33b	17.33ab	0.19b
SoV - d.f -					
Replication 2	1.48	13.48	1.00	28.0	0.005
Varieties 2	2.28	17.37	7.00*	25.0*	0.044*
Error 22	1.32	15.30	0.09	4.37	0.0004
CV	11.56	10.92	9.64	14.71	10.35

Means Followed by a common letter are not statistically different ($p<0.05$)
* Significant ($p<0.05$)

Suleman 96 was higher in yielding mean tiller as well as leaf number per plant, followed by Nowshera 96 and Khyber 87. However, this slight variation in tiller and leaf number per plant was statistically not-significant ($p<0.05$). Data regarding leaf and stern masses (g/plant) showed a strong significant ($p<0.05$) variation for the varieties. Nowshera 96 produced significantly ($p\leq0.05$) the highest leaf mass, followed by Khyber 87. However the Suleman 96 ranked third in leaf mass production on single plant basis. This ranking order of the varieties for leaf masses did not match for the stem masses. The stem masses data revealed that Suleman 96 yielded the highest weight ($p\leq0.05$) followed by Khyber 87 and the minimum Nowshera 96. As the leaf to stem ratio was calculated from the previous data recorded for leaf and stem determination and the variety order to yield the leaf mass was not the same as it was for the stem mass therefore, the leaf stem ratio varied for the treatment varieties.

Statistical analysis for data regarding flag leaf area showed that different varieties were significantly varied in developing flag leaf during the vegetative growth (Table 2). Nowshera 96 dominated the other two varieties in developing flag leaf area. The flag leaf area in Nowshera 96 and Khyber 87 were found non-significant. However, Suleman 96 was significantly lower in flag leaf area development than Nowshera 96 and/or Khyber 87. Spike weight of a variety is dependent characters on flag leaf area of the corresponding tiller of a variety and hence, in this experiment mimicked almost similar results as reported in the flag leaf area. Nowshera 96 and Khyber 87 were nonsignificant from each other for spike weight data but statistically greater ($p<0.05$) than Suleman 96. For 1000 grains weight estimation, all varieties were significantly differed from each other. Nowshera 96 was the leading varieties in yielding the highest grain weight ($p<0.05$), followed by Suleman 96. Variety Khyber 87 was the lowest among all varieties in yielding statistically the minimal 1000 grains weight. The above ground biomass and seed yield are the most important characters of wheat plant and both were significantly differed due to varieties genotypes. The ranking order of biomass yield and grain yield were significantly highest for Nowshera 96, followed by Suleman 96. Variety Khyber 87 ranked third by producing significantly lower biomass or grain yield as compared to the other two varieties. Harvest index did not significantly influenced among the varieties in this experiment.

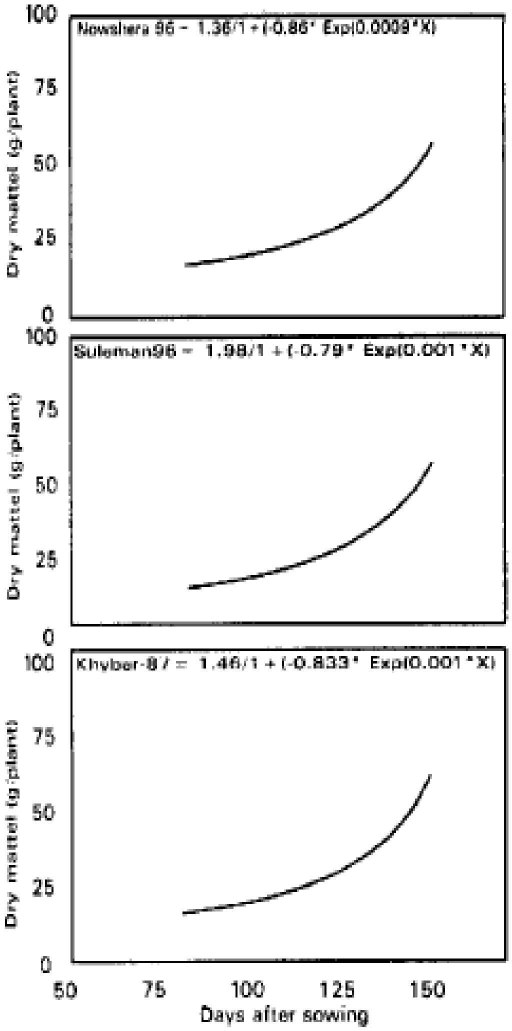
Table 2: Data regarding wheat flag-leaf area, spike weight, 1000-grains weight, biomass and grain yield and harvest index observed on three recommended wheat varieties at the NWFP Agriculture University in 1999

Varieties	Flag leaf area (m_2/leaf)	Spike weight (g/tiller)	1000 grains weight (g)	Biomass (kg/ha)	Grain yield (kg/ha)	Harvest index (%)
Nowshera-96	30.11a	5.33a	59.00a	11527a	4858a	0.42a
Suleman-96	25.86a	4.68b	53.33b	10277b	416Th	0.41a
Khyber-87	30.82b	5.68a	47.33c	08708c	3583c	0.41
SoV - d.f. -						
Replication 2	13.64	1.33	0.44	5658	3583	0.0007
Varieties 2	64.56*	2.33*	102.11*	258658	53033*	0.0004
Error 22	12.18	0.42	0.93	3779	297	0.0009
CV	00.72	14.63	4.25	5.91	4	8.55

Means followed by a common letter are not statistically different p <0.05>, * Significant (p < 0.05 >

Discussion

As expected, mean leaf and tiller number per plant was not significantly ($p\leq0.05$) affected among varieties at the anthesis stage of vegetative growth. We tried our best to provide uniform agronomic and climatic requirements for growth and development of plants of the three varieties. Additionally, plants were manually thinned right after emergence to provide uniform spacing to the seedling which reflected a non significant leaf and tiller number per plant for the 3 different varieties. Tillering rate is a function of bud formation and development and the substrate available to these buds during growth and development of the plant (Van Loa, 1993). Though the soil fertility status, water supply., species, climatic conditions and sowing time was uniformly applied, the plant potential to develop tiller and leaf per plant were remained non-significant for any of the variety. Tillering rate per plant is closely associated with light availability at the base of that plant (Davies and Thomas, 1983) and we tried our best to adjust plant to plant as well as row to row distances for each variety and hence expected a non significant results for tiller number. Moreover, leaf development is coordinated with other leaves and tillers within the plant (Hay and Kemp, 1990; Kirby, 1990) and tiller of a cereal has the capacity to sustain a certain number of leaves on that. Thereafter, each new leaf initiation resulted cause of senescence of the oldest leaf on that tiller (Davies and Thomas, 1983; Nemoto *et al*., 1995). This non-significant leaf and tiller per plant further make possible to establish a non-significant growth rate of the three varieties recorded during vegetative development. Cereal's leaf blade is the major source of assimilates



Fig, 1: Seasonal dry matter increment in wheat varieties during the vegetative growth phase

production during growth and is called as source factory. Assimilate produced during photosynthesis is trans-located into different plant parts. This rate of assimilate distribution within different parts is plant internal assessments for each organ (Paez and Gonzalez, 1995). The significant variation in leaf and stem mass of this experiment established that the three tested varieties were different in assimilates distribution to leaf and stem. However, wheat yield is product of the grain numbers and their weight per spike. It is also known that when spike development started all plant attention focussed for viable seed production and likewise assimilates contribution is higher for grain development. This reflected higher returns as yield per spike of the variety. High leaf mass of the variety resulted high assimilates contribution as well as high spike weight per tiller as well as single grain weight. It is assumed that flag leaf area contribution is the highest than other leaves during spike development (Passioura, 1994; Bewley and Black, 1994) and is proved by the results of this experiment for all varieties but Khyber 87. Khyber 87 was the leading variety in developing flag leaf area but its duration was not as long as the duration recorded for Nowshera 96 and Suleman 96. The Nowshera-96 was the leading variety in developing high leaf mass per tiller as well as flag leaf area and duration and hence considered to be the potential variety if optimum nutritional and water requirements were supplied during the growth. We also recommend further investigation for plant population and fertilizer combination interaction studies for Nowshera 96 and Suleman 96. This will enable the growers to get maximum efficiency of each leaf produced on module to contribute in grain development.

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