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Response of Late Sown Wheat to Seeding Density and Nitrogen Management

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Abstract: The seeding rates were 100 and 150 kg ha^{-1} while the nitrogen levels comprised 100, 150 and 200 kg ha^{-1} with five split application treatments viz. full at sowing, full with first irrigation, half at sowing and half with first irrigation, two third at sowing + one third with first irrigation and one third at sowing + One third with first irrigation + one third with second irrigation along with a basic dose of 100 kg ha^{-1} each of P and K applied at sowing. The crop was planted on December 19. The highest grain yield of 3585 kg ha^{-1} was obtained from plots given nitrogen full at sowing at 150 kg ha^{-1} followed by 3334 kg ha^{-1} in plots given nitrogen in two splits i.e., two third at sowing and one third with first irrigation. However, higher seeding rate (150 kg ha^{-1}) tended to increase grain yield ha^{-1} with a nitrogen rate of 150 kg ha^{-1}. By contrast, grain protein contents were the highest (12.26%) in crop fertilized with 150 kg ha^{-1} full at sowing and seeded at 100 kg ha^{-1}.

Key words: Seeding density, Nitrogen management, Late sown wheat

Introduction

In Pakistan, under the changed cropping patterns, farmers have started growing wheat after cotton, maize and rice, as a result of which sowing of wheat often gets delayed which results in a considerable reduction in wheat yield. With delay in sowing from first November to seventh January, a decrease of 268 kg to 2165 kg ha^{-1} in grain yield of wheat has been observed (Randhawa and Singh, 1973). Similarly Afzal and Nazir (1986) reported 12.92 to 15.10 percent decrease in wheat yield due to late sowing. This necessitates to develop some agro-techniques which may lead to increased productivity of wheat under late sown conditions. Nutrition management is of special importance in late sown wheat because of limited growing period. Among the nutrient elements, nitrogen is of special significance. Not only its increased rate but also appropriate time of its application and judicious combination with other essential nutrients go a long way to enhance wheat production and its quality. Moreover, efficient use of nutrients is also associated with normal planting density of the crop which should be wisely worked out especially in case of late planting.

Materials and Methods

A field study to determine the effectiveness of nitrogen when applied in splits at different rates to late sown wheat planted at variable seeding density, was conducted at the University of Agriculture, Faisalabad on sandy-clay loam soil with initial fertility status of 0.039 percent N, 5.5 ppm P_2O_5 and 210 ppm K_2O. The nitrogen rates comprised 100, 150 and 200 kg ha^{-1} while the split application treatments were full at sowing, full with first irrigation, half at sowing and half with first irrigation, two third at sowing + one third with first irrigation and one third at sowing + one third with first irrigation + one third with second irrigation. The seeding densities were 100 and 150 kg ha^{-1}. A basal dose of 100 kg ha^{-1} each of P_2O and K_2O in the form of single super phosphate and sulfate of potash, respectively was applied full at sowing. Whereas nitrogen was used as urea. The experiment was laid out in a split plot arrangement randomizing the split application treatments in the main plots, nitrogen rates in the sub-plots and seeding densities in the sub-subplots. The net plot size measured 3×12 m. Wheat cultivar Pak-81 was used as a medium of the trial. The crop was sown on 19th of December in 45 cm spaced paired rows with 15 cm space between the rows in a pair (15/45 cm). All other agronomic operations except the ones under study were kept normal and uniform for all the treatments. Observations on yield and yield parameters were recorded by using standard procedures. Harvest index was computed by using the following formula:

$$H.I = \frac{\text{Economic yield ha}^{-1}\text{ (Grain Yield)}}{\text{Biological yield ha}^{-1}} \times 100$$

Total nitrogen in grain was estimated by Gunning and Hibbard's method of H_2SO_4 and distillation was made with micro Kjeldahl apparatus. Thereafter crude protein was calculated by multiplying total nitrogen with 6.25.

The data obtained were statistically analyzed using Fisher's analysis of variance technique and Duncan's new Multiple Range Test at p = 0.05 was employed to compare the differences among treatment means (Steel and Torrie, 1984).

Results and Discussion

The data pertaining to different agronomic traits and grain protein contents of wheat given in Table 1 revealed that the number of spikes m^{-2} was affected significantly by different seeding densities, nitrogen levels and times of application. There were significantly more number of spikes m^{-2} (488.44) at higher seeding density (150 kg ha^{-1}) than at low seeding rate (100 kg ha^{-1}) which was attributed to greater number of initial seedings m^{-2} as a result of more number of seeds per unit area. These results support the findings of Smid and Jenkinson (1979) and Wali and Whab (1987). Although increase in nitrogen rate from 100 to 150 kg ha^{-1} caused significant increase in spikes m^2 but it tended to decrease beyond the level of 150 kg ha^{-1} probably because of lodging and tillers mortality. Nitrogen application full at sowing produced significantly the maximum number of spikes m^{-2} against the minimum in plots given nitrogen in three equal splits. These results are in conformity with those of Ahmad and Nazir (1978), Malik (1981) and Maqsood *et al*. (1999).

The interaction of $A \times N$, $S \times A$ and $A \times N \times S$ was significant. Regarding $A \times N$ interaction, regardless of the time of application, N_2 (150 kg N ha^{-1}) produced significantly the maximum number of spikes m^{-2} except A_2N_3 and A_5N_3 which were at par with each other. Similarly the interaction of S×A indicated that A_1 (N full at sowing) gave significantly the highest number of spikes m^{-2} irrespective of the seeding rates. So for as the interaction of A×N×S is concerned, it was observed that combination of A_1,N_3S_2, A_1,N_3S_2, $A_2N_3S_2$, $A_3N_2S_2$, $A_4N_2S_2$, $A_4N_2S_2$, $A_4N_2S_2$, $A_4N_3S_2$, $A_2N_2S_2$, A_5N_3S and $A_5N_3S_2$ although produced significantly more number of spikes m^{-2} than rest of the combinations but were at par with one another. This clearly indicated that application of 150 kg N ha^{-1} with a seeding rate of 200 kg ha^{-1} irrespective of the time of N application appeared to be the best combination in respect of the number of spikes m^{-2}.

The different nitrogen rates, seeding densities and times of nitrogen application affected the grains $spike^{-1}$ significantly. Nitrogen application in three equal splits although produced significantly more number of grains spike than that applied either full with first irrigation or half at sowing and half with first irrigation but was at par with that applied either full at sowing or two third at sowing+one third with first irrigation.

Among the nitrogen rates, 150 kg N ha^{-1} produced more grains $spike^{-1}$ than that of 100 or 200 kg N ha^{-1}. Differences in the number of grains spike due to variable nitrogen rate has also been reported by Singh and Yadav (1976) and Malik and Shah (1997). The number of grains spike decreased significantly with an increase in seeding density from 100 to 150 kg ha^{-1}. The reason for this decline was probably the hard competition among the plants for moisture and nutrients due to more number of tillers per unit area. Time of N application had significant effect on 1000-grain weight. Nitrogen applied full at sowing gave significantly the highest 1000-grain weight (37.32 g) followed by that applied either two third at sowing+one third with first irrigation (35.90 g) or full with first irrigation (35.30 g) which were on a par with each other. Significantly the minimum 1000-grain weight (32.70 g) was recorded in the treatment of half at sowing+half with first irrigation being at par with the treatment of one third at sowing+one third with first irrigation+one third with second irrigation (33.70 g). These differences might be attributed to variable nitrogen utilization efficiency of wheat plants given nitrogen fertilizer at various growth stages in single or split doses.

Among the N rates, crop fertilized at 150 kg N ha^{-1} produced significantly heavier grains than 100 and 200 kg N ha^{-1}. Decrease in 1000-grain weight beyond 150 kg N ha^{-1} was ascribed to lodging due to heavy N-fertilization.

Seeding density had also significant effect on 1000-grain weight which decreased progressively with an increase in seeding density from 100 to 150 kg ha^{-1}. This was also ascribed to hard competition among the plants due to higher plant density per unit area. These results are quite in line with the findings of Harbir (1984) and Sadiq and Lalah (1986).

The interaction between A×N was also significant. Nitrogen applied at 150 kg ha^{-1} produced significantly the heaviest grain irrespective to its time of application. Similarly the interaction of A×N×S was found to be significant. Plots seeded at 100 kg ha^{-1} and fertilized with 150 kg ha^{-1} produced significantly heavier grains regardless of the time of N application. These results are in accordance with those of Barberis (1985) and Kumar (1986). Single and split application of N had significant effect on grain yield ha^{-1}. Nitrogen applied either full at sowing or two third at sowing+one third with first irrigation gave significantly higher grain yield ha^{-1} than that applied either full with first irrigation or half at sowing+half with first irrigation or one third at sowing+one third with first irrigation+one third with second irrigation which were in turn on a par with one another. Similar results were reported by Sinka (1975), Singh and Yadav (1976) and Muhammad *et al*. (1986).

Among the N rates, crop fertilized at 150 kg N ha^{-1} produced significantly more grain yield (3080 kg ha^{-1}) than that produced by 100 or 200 kg N ha^{-1} which amounted to 2762 and 2904 kg ha^{-1}, respectively differing significantly from each other. The results further led to the conclusion that N application beyond 150 kg ha^{-1} did not increase wheat grain yield but in contrast tended to decrease it under late sown conditions. These findings are in consonance with those of Malik (1981), Kumar (1986), Malik and Shah (1997) and Maqsood *et al.* (1999).

Seeding densities affected the grains yield significantly. Seeding at the rate of 150 kg ha^{-1} gave significantly higher grain yield (3101 kg ha^{-1} than that seeded at 100 kg ha^{-1} (2729 kg ha^{-1}) These results are similar to the findings of Abd-El-Gawad *et al*. (1986) and Sadiq and Lalah (1986).

Table 1: Effect of seeding density and split application of nitrogen at different rates on yield yield components and grain protein content of late sown wheat

Treatments	Spikes m^{-2}	Grains $spike^{-1}$	1000-grain wt (g)	Grain Yield (kg ha^{-1})	Harvest index (%)	Grain protein contents (%)
A Application Time						
A_1-Full at sowing	498 a	36.3 ab	37.3 a	3119 a	40.8 b	11.28 a
A_2-Full with first irrigation	448 c	33.5 c	35.3 b	2820 b	40.5 b	10.93 b
A_3-Half at sowing+half with first irrigation	454 b	34.5 be	32.7 c	2779 b	39.7 c	10.99 b
A_4-two third at sowing+two third with first irrigation	465 b	36.2 ab	35.9 b	3045 a	42.9 a	10.46 c
A_5-One third at sowing+one third with first irrigation+one third with second irrigation	430 d	37.0 a	33.7 c	2817b	40.5b	1041 c
B-Nitrogen rates (kg ha^{-1})						
N_1 = 100	432 c	30.2 c	30.5 c	2726 c	41.5 a	10.60 b
N_2 = 150	486 a	36.8 a	40.5 a	3080 a	41.1 a	11.70 a
N_3 = 200	458 b	32.6 b	34.0 b	2904 b	40.0 b	11.54 a

C-Seeding density (kg ha^{-1})						
S_1 = 100	429 b	36.1 a	38.0 a	2729 b	40.6 b	11.34 a
S_2 = 150	488 a	34.9 b	32.0 b	3101 a	41.1 a	10.29 b
D-Interactions						
A_1N_1	473 b	29.9 c	39.6 b	3068 b	40.6 ab	10.60 b
A_1N_2	530 a	38.2 a	42.7 a	3085 a	41.5 a	11.70 a
A_1N_3	492 b	34.9 b	38.6 b	2904 b	40.2 b	11.54 a
A_2N_1	425 b	29.3 c	32.5 b	2608 b	41.2 a	10.00 b
A_2N_2	457 a	39.9 c	40.3 a	2849 a	39.6 b	11.44 a
A_2N_3	462 a	31.4 b	32.2 b	3002 a	40.7 a	11.36 a
A_3N_1	430 b	30.2 b	30.7 b	2753 ab	41.6 a	1013 b
A_3N_2	514 a	38.1 a	38.2 a	2899 a	40.2 b	11.41 a
A_3N_3	417 b	31.2 b	31.3 b	2686 b	37.5 c	11.42 a
A_4N_1	429 b	30.8 c	32.8 b	2824 b	42.7 a	09.67 a
A_4N_2	498 a	38.1 a	41.6 a	3334 a	43.3 a	10.64 b
A_4N_3	457 b	32.7 b	34.0 b	2977 b	42.9 b	11.07 a
A_5N_1	394 c	31.8 b	33.5 b	2556 n	41.5 a	09.69 c
A_5N_2	432 b	39.1 a	38.8 a	2932 a	41.1 a	10.38 b
A_5N_3	463 a	32.7 b	34.8 b	2939 a	38.8 b	11.16 a
S_1A_1	466 a	-	-	2915 a	40.6 c	11.71 a
S_1A_2	418 d	-	-	2709 b	41.2 b	11.56 a
S_1A_3	429 b	-	-	2571 c	39.7 d	11.55 a
S_1A_4	423 c	-	-	2998 a	42.8 a	10.87 b
S_1A_5	409 c	NS	NS	2552 c	38.7 c	10.59 a
S_2A_1	520 a	-	-	3334 a	40.9 c	10.58 a
S_2A_2	478 c	-	-	2930 d	45.8 d	10.31 b
S_2A_3	478 c	-	-	2988 d	39.7 d	10.43 b
S_2A_4	506 b	-	-	3192 b	43.1 a	10.05 c
S_2A_5	450 d	-	-	3072 c	42.2 a	09.82 d
S_1N_1	-	-	-	2563 c	40.9 a	-
S_1N_2	-	-	-	2863 a	40.6 ab	-
S_1N_3	-	-	-	2761 b	40.3 b	-
S_2N_1	-	-	-	2960 c	42.1 a	-
S_2N_2	-	-	-	3297 a	41.6 a	-
S_2N_3	-	-	-	3046 b	39.6 b	-
$A_1N_1S_1$	453c	-	31.8c	-	38.3 d	10.80 b
$A_1N_1S_2$	494 b	-	30.9 c	-	43.0 a	10.40 c
$A_1N_2S_1$	499 b	-	42.4 a	-	42.8 a	12.56 a
$A_1N_2S_2$	561 a	-	38.9c	-	40.1 b	11.13 b
$A_1N_3S_1$	447 c	-	40.8 b	-	40.8 b	12.07 a
$A_1N_3S_2$	536 a	-	35.4 d	-	39.5 c	11.02 b
$A_2N_1S_1$	393 c	-	34.4 c	-	41.6 a	10.73 b
$A_2N_1S_2$	456 b	-	30.6 d	-	40.9 b	9.27 c
$A_2N_2S_2$	433 b	-	41.9 a	-	39.6 c	12.05 a
$A_2N_2S_2$	481 a	-	37.6 b	-	39.5 c	10.83 b
$A_2N_3S_1$	429 b	-	36.6 b	-	42.5 a	11.91 a
$A_2N_3S_2$	495 a	-	29.9 d	-	38.9 c	10.00 b
$A_3N_1S_1$	396 c	-	30.7 c	-	40.6 b	10.88 b
$A_3N_1S_2$	464 b	-	28.6 d	-	42.5 a	9.38 c
$A_3N_2S_1$	480 b	-	41.5 a	-	39.9 bc	11.81 a
$A_3N_2S_2$	547 a	-	34.8 b	-	40.4 b	11.01 b
$A_3N_3S_1$	410 c	-	34.0 b	-	38.7 c	11.95 a
$A_3N_3S_2$	423 c	-	28.6 cd	-	36.2 d	10.99 d
$A_4N_1S_1$	408 c	-	35.5 bc	-	42.9 a	9.96 d
$A_4N_1S_2$	471 b	-	28.7 c	-	42.5 a	9.37 c
$A_4N_2S_1$	460 b	-	43.2 a	-	42.1 a	11.09 b
$A_4N_2S_2$	535 a	-	37.9 b	-	43.4 a	10.19 b
$A_4N_3S_1$	402 c	-	35.0 cd	-	42.4 a	11.36 a
$A_4N_3S_2$	512 a	-	33.0 de	-	43.3 a	10.58 c
$A_5N_1S_1$	361 c	-	32.4 c	-	41.3 bc	10.28 c
$A_5N_1S_2$	427 b	-	28.5 b	-	41.8 b	10.09 c
$A_5N_2S_1$	399 b	-	42.1 a	-	37.5 b	11.31 a
$A_5N_2S_2$	464 a	-	35.5 b	-	44.6 a	9.46 d
$A_5N_3S_1$	466 a	-	37.2 b	-	37.3 d	11.40 a
$A_5N_3S_3$	460 a	-	28.4 d	-	40.3 c	10.91 b

Within a column any two means not sharing the same letter differ significantly from each other at $p = 0.05$, NS = Non-significant

The interaction of A × N was also significant. Application of 150 kg N ha^{-1} irrespective to its time and mode of application produced significantly higher grain yield ha^{-1} than rest of the combinations in each set of treatments. Similarly interactions of S × A and S × N were significant. Application of N full at sowing or two third at sowing + one third with first irrigation irrespective of the seeding rates produced significantly higher grain yield ha^{-1} than rest of the combinations.

As regards S × N, a nitrogen dose of 150 kg ha^{-1} at both the seeding rates (100 and 150 kg ha^{-1}) gave significantly more grain yield ha^{-1} than all other combinations. Harvest index was affected significantly by time and mode of nitrogen application. Nitrogen applied two third at sowing + one third with first irrigation gave significantly higher harvest index (42.9%) than rest of the treatments against the minimum of 39.7 percent in plots given nitrogen half at sowing + half with first irrigation.

Regarding nitrogen rates, application of 200 kg N ha^{-1} gave significantly lower harvest index (40.0%) than 150 or 100 kg N ha^{-1} which were at par with each other and gave harvest index 41.1 and 41.5 percent, respectively.

Similarly seeding rates had significant effect on harvest index. Crop seeded at 150 kg ha^{-1} gave significantly higher harvest index than that seeded at 100 kg ha^{-1}.

The interaction of A × N, S × A and A × N × S in respect of harvest index were also significant. Though significantly higher index was recorded in case of A_1N_2, A_2N_1 A_2N_3, A_3N_1, A_4N_2, A_5N_1 and A_5N_2 than rest of the combinations yet did not differ from one another. Similarly S_1A_4, S_2A_4 and S_2A_5 gave significantly more harvest index than all other combinations. Among the S × N combinations, S_1N_1, S_1N_2, S_2N_1 and S_2N_2 had significantly greater harvest index than rest of the combinations.

As regards A × N × S interactions, although $A_1N_2S_1$, $A_2N_3S_1$, $A_2N_2S_1$, $A_2N_3S_1$, $A_3N_1S_2$, $A_4N_1S_1$ $A_4N_1S_2$, $A_4N_2S_1$, $A_4N_2S_2$, $A_4N_2S_2$, $A_4N_3S_1$, $A_4N_3S_2$ and $A_5N_2S_2$ gave significantly higher harvest index than all other combinations but were at par with one another.

Protein contents in grain: Time and mode of nitrogen application had significant effect on grain protein content. Significantly the maximum grain protein content (11.70%) was recorded in plots given full nitrogen at sowing followed by that given half at sowing and half with first irrigation (10.99%) or full with first irrigation (10.93%) against the minimum of 10.41 percent in plots receiving nitrogen in three equal splits i.e. one third at sowing + one third with first irrigation + one third with second irrigation. This was probably ascribed to low fertilizer-use efficiency in case of split application especially in late sown wheat because of high volatilization losses.

Among the nitrogen rates, the maximum grain protein content (11.70%) was obtained with the application of 150 kg N ha^{-1}. Increase in grain protein content with an increase in nitrogen dose was also reported by Berkutova and Vinogradova (1982) and Malik and Shah (1997).

Seeding density also had significant effect on grain protein content. Crop seeded at 100 kg ha^{-1} produced grain with significantly higher protein content (11.34%) than the crop seeded at 150 kg ha^{-1} This indicates that N-utilization efficiency at appropriate seeding density is more than that at higher seeding density.

The interaction between A × N, S × A and A × N × S was also significant. As regards interaction of A × N, A_1N_2 produced grain with maximum protein content (11.70%) followed by A_1N_3 recording 11.54 percent protein content in grain. However, these two combinations were at par with each other. The lowest content of 9.57 percent was recorded for A_4N_1 against 9.69 protein percent for A_5N_1. Similarly in case of S × A interaction, S_1A_2 produced the highest protein content (11.71%) but it was statistically at par with S_1A_2 and S_1A_3. The interaction of A × N × S revealed that $A_1N_2S_1$, gave the highest protein content (12.26%) followed by $A_1N_3S_1$, (12.07%) showing non-significant difference. However, these two combinations differed significantly from rest of the combinations.

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