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Effect of cultivars and split application of nitrogen at the different growth stages on yield and its component of bread wheat (*Triticum aestivum* L.) under rain-fed conditions in Kurdistan, Iraq

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Abstract

To investigate the best N fertilizer application regime for the environment and the economy. Therefore, a field experiment was conducted for one year (2020–2021) under the rain-fed condition at two locations in the Sulaimani region; Qlyasan research field of the College of Agriculture Engineering University of Sulaimani and the Kanipanka research station in the Sharazoor valley to determine the effect of the application of 120 kg ha-1 N in four split doses (T6) at four growing stages, sowing, tillering, booting, and spiking, respectively. Were T1 (60 kg ha-1 N at sowing, 60 kg ha-1 N at tillering) used as a control, T2 (60 kg ha-1 N at sowing, 30 kg ha-1 N at tillering, 30 kg ha-1 N at booting), T3 (60 kg ha-1 N at sowing, 30 kg ha-1 N at tillering, 30 kg ha-1 N at spiking), T4 (60 kg ha-1 N at sowing, 20 kg ha-1 N at tillering, 20 kg ha-1 N booting, 20 kg ha-1 N at spiking), T5 (40 kg ha-1 N at sowing,30 kg ha-1 N at tillering, 30 kg ha-1 N at booting, 20 kg N ha-1 N at spiking) and T6 (40 kg ha-1 N at sowing, 40 kg ha-1 N at tillering, 40 kg ha-1 N at booting) and their effect on grain yield and it's components of bread wheat cultivars (Adana-99, Hawler-4, and Sulaimani-2). A split plot arrangement within Randomimized Complete Block Design with three replicates was used. The possible comparison among the means was calculated following the Duncan test at a significant level of 0.05. As part of grain yield, no. of spikes m-2, no. of grains.spike, thousand-grain weight (g) (TGW), grain yield ton ha-1 (GY), biological yield ton ha-1 (BY), and Harvest Index (H.I) were all calculated. As the average of both locations of the results showed that the impact of Cultivars on agronomic traits was significant, Sulaimani-2 produced the maximum values for all characters, with the exception of (TGW) and (H.I), which were provided by Hawler-4. All the bread wheat characters were significantly influenced by the time of application of nitrogen, where T5 produced the maximum value for all characters with the exception no. of spike m-2, where T6 had the ultimate value. The no. of spikes m-2 had a significant effect on the T4, and T5 study characters. Based on what we've found, the best combination is

Sulaimani-2 with T6 and T5 except in Qlyasan location with T6 only when rain is guaranteed. This increases both the yield and its components.

Keywords: Wheat variety, split application of nitrogen, growing stages, yield and yield component

Introduction

Wheat is an important source of energy and a staple food in the human diet, providing wheat for around 30% of world grain production and 44% of global cereal production, Faostat [1]. Just like with any other crop, wheat output can be boosted by planting high-yielding varieties. Variety contributes more than half of the increased output [2]. Many researchers [3, 4, 5, 6, 7, 8, 9] reported that wheat genotypes had a significant impact on the no. of spikes m-2, no. of grains. spike, thousand grain weight, harvest index, and grain yield. How and when N fertilizer is used has a big effect on the amount of wheat grain that grows [10].

Cereal crops have a nitrogen use efficiency of around 33%, indicating that N fertilizer is not completely utilized by the crop. It was reported previously [11, 12] that nitrogen that the crop didn't consume could be expelled into the atmosphere through gaseous emissions, soil denitrification, volatilization, or leaching below the root zone. Nitrogen deficits are common in crops at times when they are most needed, so nitrogen application at that time is expected to increase nitrogen use efficiency and profitability [13]. Excessive N application can be reduced by using N fertilizer at the proper rate and at the appropriate time, resulting in a financial benefit to farmers through increased output [14], fertilizer savings, and a reduction in environmental hazards [14, 15]. The crop N need sharply rises just before the start of the fastest phase of crop growth, stem elongation. Shoot mortality is higher, and spike size is less, due to a lack of N during this phase and following shoot development. The greatest nitrogen rate, 120 kg ha-1, consistently enhanced grain output while having a lesser impact on the harvest index. With a 120 kg ha-1 split nitrogen rate per hectare, Split nitrogen treatment increased grain yield and total biomass [16].

Split nitrogen application is one of the methods for improving crop nitrogen use while reducing nutrient loss due to leaching, denitrification, runoff, and volatilization [17]. Some discoveries from research [18] show that nitrogen recovery and utilization efficiency were increased by late-season nitrogen application as a dry fertilizer material. Furthermore, establishing the optimum nitrogen fertilizer rates and timing is crucial for increasing yields [19]. Little study has been done on the impact of split nitrogen delivery on wheat grain output and nitrogen utilization efficiency in various parts of the glope [20]. The timing of N fertilizer application is determined by the soil, climate, nutrients, and cultivar; crops should be fertilized at a time that maximizes crop recovery while minimizing environmental pollution [21]. One method for attempting to achieve a high-yield goal is to apply nitrogen fertilizer at the right time to high-yielding Varity [22]. Wheat Cultivars differ in their response to nitrogen (N) fertilizer, both in terms of its uptake and utilization [23]. The aim of the present research was to observe the impact of the split application of N fertilizer on grain yield and its components for different wheat Cultivars as well as to determine the best combination of variety and N time of application under experimental conditions

Materials and methods

The experiment was conducted at the University of Sulaimani Qlyasan Agriculture Research Station College of Agriculture and Engineering Science in southwest Sulaimani city (latitude 35̊34′ 307″; N,Longitude 45̊21′ 992″; E, 765 MASL) two kilometers to the northwest of Sulaimani City and the kanipanka Research Station (Latitude 35̊22′; N, Longitude 45̊43′; E, 550 MASL), 35 kilometers east of Sulaimani city, in the Shahrazoor valley, during the period from Novembers 2020 to May 2021 to study the effect of the application of 120 kg ha−1 N in four split doses (T6) at four growing stage, sowing, tillering, booting and spiking respectively, as shown in table (1) and their impact on grain output and the components of three bread wheat Cultivars (Adanna-99, Hawler-4, and Sulaimani-2) were chosen for cultivation and made available by the Bakrajo-Agricultural Research center, specifically (Adana-99, Hawler-4, Sulaimani-2). Adana-99 cultivar introduced from Turkey has had a high yield potential in the last decade, Sulamani-2 cultivars have been obtained from Bakrajo Research Center in Sulaimani, and Hawler-4 produced at the Hawler station research, was cultivar in Kurdistan region high adapted to Kurdistan Environmental condition. The experiment was laid out using three replicates of a split-plot Completely Randomized Block Design (CRBD). The possible comparison among the means was calculated following the Duncan test at a significant level of 0.05. No. of spike m-2, no. grain/ spike, thousand grien whieght (TGW) (g), grian yield (GY) ton ha-1, biological yield (BY) ton ha-1, and harvest index (H.I), were all calculated as part of grain yield and its component, the seeds were sown on November 23rd and 24th for Qlyasan and Kanipanka locations respectively. Seeds were sown continuously in-furrow at the rate of 160 kg ha-1.

Table (1): The application of 120 kg N ha^{-1} in six split doses at four growing stages, sowing, tillering, booting and spiking respectively

Treatments	Wheat growth stages			
	Sowing	Tillering	Booting	spiking
T1	60	60	0	0
T2	60	30	30	0
T3	60	30	0	30
T4	60	20	20	20
T5	40	30	30	20
T6	40	40	40	0

Results and Discussion

Data represented in Appendix (1) and Table (2) at the Qlyasan location showed that three cultivars significantly affected study characters. The C2 cultivar showed the maximum value for the no. of the spike m^{-2}, TGW, GY, and H.I, with (309.815, 26.024 g, 2.487 tons ha-1, and 34.253%) respectively, while the C3 ultivar recorded the maximum value for the no. of grain/spike and BY, with (40.341 and 7.944 tons ha^{-1}) respectively, while the C1 cultivars showed the minimum value for all characters. However, at the Kanipanka location, the effect of wheat cultivars on yield and its components has been significantly reported in (Table 2, and Appendix 1). The C3 variety showed the maximum value for the no. of spikes m, no. of grains/ spike, GY, BY, and H.I, with (430.463, 43.656, 5.434 tons ha^{-1}, 13.547 tons ha^{-1}, and 40.201%) respectively, while the C2 cultivar recorded the maximum value for the TGW, with (37.831 g) followed by C3. The C1 cultivar showed the minimum value for all characters except the no. of grains/ spike, while the C2 cultivar recorded a minimum value for the no. of grains/ spike of (42.172). This study discovered that three varieties differed significantly for the studied characters on average in both locations (Table 2 and Appendix 1). Cultivar C3 had the highest values for the no. of spikes m^{-2}, grains/ spike, GY, BY, and H.I, with (365.278 m-2, 41.998 $spike^{-1}$, 3.955 tons ha^{-1}, 10.745 tons ha^{-1} and 36.807%), respectively, while cultivar C2 had the highest value for the TGW with (31.928 g), and cultivar C1 had the lowest value for all characters. These results are in disagreement with the Adanna-99 cultivar with those obtained by [24]. Different varieties' effects on reproductive traits may vary depending on various physiological and developmental processes that take place during the growing cycle. These variations can be attributed to three main components, including, the no. of spikes/ unit area, the no. of grains/ spike, and grain weight, or under high tillering conditions. [25,26]. Del Moral and Rharrabti [27] reported the TGW, the no. of grains/ spike, and the no. of spikes. The genetic makeup, which is significantly influenced by environmental factors under nitrogen fertilizer, may be the primary cause of the yield variation between wheat genotypes. The yield component, the no. of spikes m^{-2}, grain/ spike, and TGW, was responsible for the highest grain yield. Components played an important role in GY's effect. Harvest index differences among wheat cultivars are due to the variable ratio of GY and biological yield of cultivars. Such results were found by Omar, Mohamed [28], El-Hawary and Shaheen [29], and Hendawy [8]. These outcomes concur with those attained by Noureldin et al [30]. The harvest index should be expected given that the same cultivar produced both the highest average biological yield and the average average GY, as well as the highest average harvest index. These outcomes concur with those attained by Noureldin and Saudy [30], [31]. The yield component value difference between the two locations revealed that the Kanipanka location provided a higher value than the Qlyasan location because the Kanipanka location is closer to sea level, about 215 m in comparison to the Qlyasan location.

Table (2): Means of reproductive characteristics in wheat cultivars

Qlyasan Location						
Cultivars	**NO. of spike.m^{-2}**	**No. of grain/ spike**	**TGW (g)**	**GY(ton ha^{-1})**	**BY(ton ha^{-1})**	**H.I%**
C1	**220.926c**	**36.272c**	**22.32c**	**1.599b**	**5.228c**	**30.457%c**
C2	**309.815a**	**38.972b**	**26.024a**	**2.487a**	**7.336b**	**34.253%a**
C3	**300.093b**	**40.341a**	**25.251b**	**2.476a**	**7.944a**	**31.248%b**
Kanipanka Location						
Cultivars	**NO. of spike.m^{-2}**	**No. of grain/ spike**	**TGW (g)**	**GY /ton ha^{-1}**	**BY ton ha^{-1}**	**H.I**
C1	**355.37c**	**43.483a**	**32.45b**	**4.223c**	**11.661b**	**36.271%c**
C2	**411.111b**	**42.172b**	**37.831a**	**5.064b**	**13.378a**	**37.875%b**
C3	**430.463a**	**43.656a**	**37.168a**	**5.434a**	**13.547a**	**40.201%a**
Average both locations						
Cultivars	**NO. of spike.m^{-2}**	**No. of grain/ spike**	**TGW (g)**	**GY(ton ha^{-1})**	**BY(ton ha^{-1})**	**H.I**
C1	**288.148b**	**39.878b**	**27.385c**	**2.911c**	**8.445c**	**34.470%c**
C2	**360.463a**	**40.572b**	**31.928a**	**3.776b**	**10.357b**	**36.458%b**
C3	**365.278a**	**41.998a**	**31.209b**	**3.955a**	**10.745a**	**36.807%a**

*C1: Adanna-99 C2: Hawler-4 C3: sulaimani-2

Qlyasan location: split nitrogen application at various growth stages significantly impacted all studied wheat characters, as reported in (Appendix1 and Table 3). Split application of nitrogen T5 displayed the maximum value for the no. of spike m^{-2} and BY, with (313.889 and 7.618 tons ha^{-1}), respectively. While T4 recorded the maximum value for the no. of grains/ spike, with 40.311, and T6 showed the maximum value for TGW, GY, and H.I with (26.650 g, 2.613 ton ha^{-1}, and 35.002%), respectively. While T1 showed the minimum value for all studied characters, with the exception no. of spike m^{-2} shown by T3, with (248.704), and T2 showed the minimum value for HI, with (27.127%). While at Kanipanka location; effected split application of nitrogen on yield and it's component in wheat was significantly reported in (Table 3 and Appendix1). The maximum value for the no. of spikes m^{-2} and BY was recorded by T6, with (426.481 and 14.327 ton ha^{-1}) respectively, while the no. of grains spike^{-1}, TGW, GY, and H.I recorded by T5 with (44.289, 37.058 g, 5.381 ton ha^{-1}, and, 40.091%) respectively, and T4 showed the minimum value for GY, BY, and H.I, with (4.292 ton ha^{-1}, 11.772 ton ha-1, and 36.352%) respectively, while T5 recorded the minimum value for the no. of spikes with (380), T3 and T1 showed the minimum value for the no. of grain/ spike with (41.511 and 41.611) respectively, and T1 recorded the minimum value for TGW with (34.436 g). On the other hand, at the average of both locations, the data recorded in (Table 3 and Appendix 1) showed that the time application of N significantly differed between study characters. Split application of N of T5 showed the maximum value for, TGW, GY, and H.I with (31.474 g, 3.976 tons ha-1, and 37.684%) respectively, while the maximum no. of spike m^{-2} and

BY was recorded by T6 with (361.852 and 10.912 tons ha-1) The highest no of grain/ spike, with 42.233 recorded by T4 and the minimum no. of grains/ spike, TWG, and BY were shown by T1, with (38.706, 28.201g, and 9.271 ton ha^{-1}) respectively, while the minimum value for GY recorded by T4 and T2, with (3.177 and 3.266 ton ha^{-1}), respectively. The minimum for the no. of spike m^{-2} was shown by T3 and T1, with (315.648 and 327.315 m^{-2}), respectively, and the minimum value for H.I with (33.649%) was recorded by T2.

The increased timing of nitrogen application and the environment coupled to create varied outcomes in GY. T5 and T6 are the best time application of nitrogen in this research. These results conflict a little with those of Mossedaq and Smith [32], They reported that when nitrogen was supplied immediately before stem elongation, the response was at its peak, and when nitrogen was applied before anthesis, it was at its lowest. Increased GYU, grains per spike, and TGW were significantly affected by four split applications, Similar findings have been reported by [33]. The choice of N timing must therefore take into account the economic aspects related to each nitrogen timing application. Since sufficient rainfall is necessary to push the N into the soil profile where it may be absorbed by the plant roots, additional safety considerations must also be taken into account for the environmental conditions required for post-applied N utilizing streamer bars. The increase in the effective no. of tillers, and grains/$Spike^{-1}$ and TGW were significantly affected by the split application, due to the availability of nitrogen at different times of their development. The same results have been reported by Wang, Cheng [34]and Pandey, Thakur [35], The grain, and biological yields were influenced significantly by the split application of nitrogen. Maximum, grain, and biological yield were recorded by nitrogen application at three splits. It can be ascribed to a rise in the number of nitrogen split applications increases the supply of N and improves plant growth and development and also contributes to increasing the photosynthetic area, which results in an increase in the yield attributing characteristics and in the end ally the grain yield. The same outcomes were also reported by [36]. This was due to the fact that spewed nitrogen application may improve wheat yield and yield component. It can be concluded that yield and its compounds were significantly increased by adding N separate growing stages compared to T1 as a control.

Table (3): The effect of split of nitrogen applications on reproductive characteristics

Qlyasan Location						
Split time application N	NO. of spike m^{-2}	No. of grain/ spike	TGW (g)	GY(ton ha^{-1})	BY(ton ha^{-1})	H.I%
T1	259.074c	35.8b	21.966e	1.755e	5.662d	32.263%c
T2	261.296c	39.133a	22.894d	1.915d	6.911b	27.127%e
T3	248.704c	36.144b	24.839c	2.207b	6.555c	33.684%b
T4	281.482b	40.311a	24.952c	2.063c	6.772bc	30.234%d
T5	313.889a	39.578a	25.889b	2.57a	7.618a	33.609%b
T6	297.222ab	40.203a	26.65a	2.613a	7.497a	35002%a
Kanipanka Location						
Split time application N	NO. of spike.m^{-2}	No. of grain/ spike	TGW (g)	GY(ton ha^{-1})	BY(ton ha^{-1})	H.I
T1	395.556bc	41.611b	34.436c	5.119b	12.88c	39.805%ab
T2	399.63b	43.378a	34.862bc	4.617d	12.502d	36.919%c
T3	382.593cd	41.511b	35.849ab	4.761c	12.207d	38.747%b
T4	409.63b	44.156a	36.507a	4.292e	11.772e	36.352%c
T5	380d	44.289a	37.058a	5.381a	13.483b	40.091%a
T6	426.481a	43.678a	36.184a	5.273a	14.327a	36.782%c
Average of both locations						
Split time application N	NO. of spike m^2	No. of grain/ spike	TGW (g)	GY(ton ha^{-1})	BY(ton ha^{-1})	H.I
T1	327.315cd	38.706b	28.201c	3.437b	9.271d	37.073%c
T2	330.463c	41.256a	28.878c	3.266c	9.706c	33.649%f
T3	315.648d	38.828b	30.344b	3.484b	9.381d	37.139%b
T4	345.556b	42.233a	30.73ab	3.177c	9.272d	34.264%e
T5	346.944b	41.933a	31.474a	3.976a	10.551b	37.684%a
T6	361.852a	41.941a	31.417a	3.943a	10.912a	36.135%d

"T1 (60 kg ha^{-1} N at sowing, 60 kg ha^{-1} N at tillering), T2 (60 kg ha^{-1} N at sowing, 30 kg ha^{-1} N at tillering, 30 kg N ha^{-1} at booting), T3 (60 kg ha^{-1} N at sowing,30 kg ha^{-1} N at tillering, 30 kg ha^{-1} N at spiking), T4 (60 kg ha^{-1} N at sowing, 20 kg ha^{-1} N at tillering, 20 kg ha^{-1} N booting, 20 kg ha^{-1} N spiking), T5 (40 kg ha^{-1} N at sowing, 30 kg ha-1N at tillering, 30 kg ha^{-1} N at booting, 20 kg ha^{-1} N at spiking) and T6 (40 kg ha^{-1} N at sowing, 40 kg ha^{-1} N at tillering, 40 kg ha^{-1} N at booting)"

Data in Table 4 (a, b, and c) and Appendix (1) demonstrated an interaction effect between the bread wheat cultivars and split application of N. The interaction significantly affects all studied characters for both locations and their average. At Qlyasan location, the maximum values of TGW and H.I with (29.525 g, and 41.067%) respectively, were exhibited by the combination of (C2 T6) and the no. of spikes m^{-2} recorded by (C3 T5) with (367.222). The maximum no. of grain/ spike shown by (C3 T6) with (43.277), maximum GY exhibited by the combination between (C2 T5, C3 T6, and C2 T6) with (2.931, 2.895, 2.892 ton ha^{-1}) respectively, and maximum BY recorded by the combination between (C2 T2) with (9.356), and the minimum no. of spike m^{-2}, grain yield, and HI recorded by (C1T2) with (200.555 m^{-2}, 1.069 ton ha^{-1} and 23.133%), while the minimum no. of grain/ spike, TGW, and BY showed by

(C1T1) with (32.433, 20.521 g, and 3.886). While at the Kanipanka location, the maximum no. of spike m^{-2}, GY, and BY were recorded by (C3 and T6) with (487.222, 5.915 tons ha^{-1}, and 15.387 tons ha^{-1}) respectively, Maximum no. of grains. spike is shown by the combination of (C3T4) with (46.3), and the maximum TGW recorded by (C2T6) with (38.677g). The maximum HI was recorded by (C3 T5) with (45.719%), while the minimum no. of spikes m^{-2} was recorded by the interaction between (C1T3) with (320.000), the minimum no. of grains/ spike recorded by (C2T3) with (38.167), the minimum TGW and HI recorded by (C1T2) with (30.861 g and 33.753%), the minimum value of GY and BY recorded by the interaction between (C1T4) with (3.398 ton ha^{-1} and 9.550). On the other hand, at the average of both locations, the maximum no. of spikes m^{-2} and the no. of grains/ spike were shown by the interaction between (C3T4) with (400.000 and 44.400), respectively. Maximum GY and BY were recorded by the interaction between (C3T6) with (4.403, 12.156 tons ha^{-1}), respectively. The maximum TGW was recorded by (C2T6) with (34.101g), and the maximum H.I was recorded by (C3T5) with (40.735 %). The minimum no. of spike m^{-2} was recorded by (C1T3) with (261.111, while the minimum no. of grains/spike and TGW was recorded by (C1T1) with (37.667 and 25.981 g) respectively, minimum GY and BY recorded by the interaction between (C1T4) with (2.23 ton ha^{-1} and 7.069 ton ha^{-1}) and minimum H.I showed by (C1T2) with (30.813%). The combination of cultivars and splitting nitrogen fertilizer had a significant influence on. the spike m^{-2}, the no. of grain/spike, TGW, GY, and BY. Similar results were obtained by[31]. Genetic variation of wheat in response to nitrogen fertilization has been reported by many workers[37]. Yield may have been increased because nitrogen was available continuously and in sufficient amounts during the plant's period of growth and development. Considering these results, it can be concluded that three N T6 splits were more beneficial for the wheat variety Sulaimani-2 under the most recent climate changes, which include a shift in precipitation distribution with a more frequent distribution during crop growth stages to reduce loss and boost wheat production. Similar outcomes were obtained by [38].

Splitting the N stimulates tillering without the increased risks of freeze damage, lodging, and disease. The second application in March would also give the wheat more N later in the spring when it is necessary for grain production. The result indicates that all mentioned characters were significantly influenced by different split applications of N and different varieties separately as well, and there were significant differences between the interaction of factors such as split time application of N and varieties for all studied characters at both locations. This was because the split time of N may enhance wheat yield and its component. Based on the obtained result, the application of T5 and Sulaimani-2 to enhance yield and its components is recommended as a split application of N or use Sulaimani-2 and T5 to increase yield and its components.

Table (4a): The combination effect of Cultivars and split time application N on reproductive characteristics

Qlyasan Location							
Cultivars	Split application N	NO. of spike m^{-2}	No. of grain/ spike	TGW (g)	GY(ton ha^{-1})	BY(ton ha^{-1})	H.I%
C1	T1	227.778h	32.433i	20.521h	1.325j	3.886l	34.133%b-d
	T2	200.555i	37.5f-h	21.284gh	1.069k	4.631k	23.133%k
	T3	202.222i	34.133i	23.749ef	1.864h	5.581j	33.400%c-e
	T4	201.667i	38.133f-h	21.267gh	1.311j	4.589k	28.600%ij
	T5	218.889hi	38.367f-h	23.6ef	1.975g	6.169i	32.067%e-g
	T6	274.444ef	37.067gh	23.5ef	2.053g	6.512gh	31.533%fg
C2	T1	257.222fg	37.533f-h	22.672fg	1.583i	4.492k	35.267%b
	T2	326.111b	39.067d-f	23.134ef	2.677c	9.356a	28.633%ij
	T3	289.444de	37.800f-h	25.459b-d	2.547d	7.642e	33.333%c-e
	T4	312.778bc	40.300c-e	26.921b	2.289e	7.236f	31.633%e-g
	T5	355.556a	38.867e-g	23.6ef	2.931a	8.239d	35.600%b
	T6	317.778b	40.267c-e	29.525a	2.895a	7.053f	41.067%a
C3	T1	292.222de	37.433f-h	22.704fg	2.358e	8.608c	27.400%j
	T2	257.222fg	40.833b-d	24.263de	2.000g	6.748g	29.633%hi
	T3	254.445g	36.500h	25.309cd	2.211f	6.442hi	34.333%bc
	T4	330.000b	42.500ab	26.669bc	2.589d	8.492cd	30.500%gh
	T5	367.222a	41.500bc	25.635b-d	2.806b	8.447cd	33.200%c-f
	T6	299.444cd	43.277a	26.925b	2.892a	8.925b	32.433%d-f

Table (4b): The combination effect of Cultivars and split of nitrogen application on reproductive characteristics

Kanipanka Location							
Cultivar	time application N	NO. of spike m^{-2}	No. of grain/ spike	TGW (g)	GY(ton ha^{-1})	BY(ton ha^{-1})	H.I%
C1	T1	320.556j	42.9e-h	31.441i	4.347hi	10.783j	40.333%c
	T2	395.555e-g	41.467g-i	30.861i	4.114i	12.194i	33.753%h
	T3	320.000j	45.667a-c	32.235hi	3.592j	10.113k	35.533%gh
	T4	366.111hi	40.933hi	33.523gh	3.389j	9.550k	35.500%gh
	T5	352.778i	45.900ab	34.623fg	5.008fg	14.079bc	35.591%gh
	T6	377.222gh	44.033b-e	32.015hi	4.889fg	13.249d-g	36.931%fg
C2	T1	443.333bc	40.267ij	36.312d-f	5.597bc	13.877b-d	40.367%c
	T2	391.111fg	42.800e-h	37.191a-e	4.967fg	12.392hi	40.084%cd
	T3	443.889b	38.167j	38.608a	5.094ef	13.438c-f	37.900%ef
	T4	392.778e-g	45.233a-d	37.748a-d	4.417h	12.627g-i	35.000%h
	T5	380.556gh	42.933efgh	38.451ab	5.294de	13.588c-e	38.965%c-e
	T6	415de	43.633c-f	38.677a	5.017fg	14.347b	34.975%h
C3	T1	422.778b d	41.667f-i	35.556ef	5.414cd	13.981bc	38.733%c-e
	T2	412.222d-f	45.867ab	36.533c-e	4.769g	12.919e-h	36.920%fg
	T3	383.889gh	40.700i	36.705b-e	5.597bc	13.071e-h	42.833%b
	T4	470.000a	46.300a	38.249abc	5.069ef	13.14e-g	38.600%c-f
	T5	406.667d-f	44.033b-e	38.101a-d	5.842ab	12.783fghi	45.719%a
	T6	487.222a	43.367d-g	37.86a-d	5.915a	15.387a	38.440%d-f

Table (4c): The combination effect of Cultivars and split of nitrogen application on reproductive characteristics

Average of both locations							
Cultivars	time application N	NO. of spike m^{-2}	No. of grain/ spike	TGW (g)	GY(ton ha^{-1})	BY(ton ha^{-1})	H.I%
C1	T1	274.167fg	37.667h	25.981j	2.836f	7.335i	38.664%d
	T2	298.055e	39.483e-h	26.073j	2.592g	8.412g	30.813%r
	T3	261.111g	39.900e-g	27.992ghi	2.728fg	7.847h	34.765%i
	T4	283.889ef	39.533e-h	27.395ij	2.35h	7.069i	33.244%q
	T5	285.833ef	42.133b-d	29.111fgh	3.491de	10.124de	34.482%m
	T6	325.833d	40.55d-f	27.757hi	3.471de	9.88e	35.132%k
C2	T1	350.278bc	38.900f-h	29.492efg	3.59d	9.184f	39.090%c
	T2	358.611b	40.933c-e	30.162ef	3.822c	10.874bc	35.148%j
	T3	366.667b	37.983gh	32.033bc	3.821c	10.54cd	36.252%g
	T4	352.778bc	42.767a-c	32.335bc	3.353e	9.931e	33.762%p
	T5	368.056b	40.900c-e	33.442ab	4.113b	10.913bc	37.689%e
	T6	366.389b	41.95b-d	34.101a	3.956bc	10.700c	36.972%f
C2	T1	357.500b	39.55e-h	29.13f-h	3.886c	11.295b	34.405%o
	T2	334.722cd	43.35ab	30.398def	3.385e	9.834e	34.421%n
	T3	319.167d	38.6f-h	31.007cde	3.904c	9.756e	40.016%b
	T4	400.000a	44.400a	32.459bc	3.829c	10.816bc	35.401%i

	T5	**386.944a**	**42.767a-c**	**31.868b-d**	**4.324a**	**10.615cd**	**40.735%a**
	T6	**393.333a**	**43.322ab**	**32.393bc**	**4.403a**	**12.156a**	**36.220%h**

Table 5 and Appendix (1) demonstrated that for all characters, the impact of locations on crop yield and wheat's component was significant. Location Kanipanka outperformed Location Qlyasan and provided the highest values of (no. of spike m^{-2}, no. of grain/ spike, TGW, GY, BY, and H.I) were (398.981, 43.104 $spike^{-1}$, 35.816 g, 4.907 ton ha^{-1}, 12.862 ton ha-1, and 38.121%), respectively, in which the lowest values of these traits exhibited by L1 were (276.944, 38.528, 24.531 g, 2.187 ton ha^{-1}, 6.836 ton ha^{-1}, and 31.994%), respectively. Light, temperature, water, humidity, and nutrition are variables that affect plant growth. The performance of wheat cultivars was not the same under both location conditions. Depending on the sensitivity of wheat cultivars to environmental changes, the results improved [39]. Yield component variation of a cultivar between both locations is due to variation of available nutrients and prevailing environmental conditions at a particular site in combination with a genetic inheritance of that cultivar. This value between both locations for all studied characters showed the Kanipanka location gave the highest value than the Qlyasan location.

Table (5): Effect of locations on the crop characters yield and yield component of wheat

Locations	‘NO. of spike m^{-2}’	No. of grain/ spike	TGW (g)	GY(ton ha^{-1})	BY(ton ha^{-1})	H.I%
Qlyasan	**276.944b**	**38.528b**	**24.531b**	**2.187b**	**6.836b**	**31.994%b**
Kanipanka	**398.981a**	**43.104a**	**35.816a**	**4.907a**	**12.862a**	**38.121%a**

The results revealed that the split application of N in four split doses (**T6**) at sowing, tillering, booting, and heading enhanced yield and components. The application of a quantity of nitrogen (120 kg ha^{-1} N) in four split doses (**T**6) was required to obtain an optimum wheat yield. To produce approximately 4.430 tons ha-1 of wheat, the soil needs up to 120 kg ha-1 N. The best yields and enhanced nitrogen recovery further supported the significance of splitting nitrogen in T5 and using the C3 Cultivar. Split nitrogen (N) fertilizer applications can help you create an effective, profitable, and environmentally responsible nutrient management strategy. In the growing years, nitrogen fertilizer caused the amount of nitrogen in the grain increased, as did the wheat crop's ability to absorb nitrogen. The best combination is Sulaimani-2 with T6 and T5 except in Qlyasan location with T6 only, grain yield more than T1 as control

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Appendix (1)

Qlyasan Location							
S.O.V	**df**	***NO. of spike***	***No of grain /spike***	**1000grian weight**	**Grain yield (ton ha-1)**	**Biological yield (ton ha-1)**	**Harvest index**
Block	2	74.228	0.205	7.01	0.005	0.006	0
A	5	5685.138**	37.040**	28.567**	1.088**	4.528**	0.007**
Ea	10	264.289	1.695	0.381	0.007	0.059	0
B	2	42789.52**	77.141**	68.716**	4.667**	36.563**	0.007**
AB	10	2871.441**	3.763**	4.226**	0.272**	4.947**	0.002**
Eb	24	102.752	0.979	0.653	0.002	0.028	0
Total	53						
Kanipanka Location							
S.O.V	**df**	***NO. of spike***	***No of grain /spike***	**1000grian weight**	**Grain yield (ton ha-1)**	**Biological yield (ton ha-1)**	**Harvest index**
Block	2	1528.833	6.269	0.358	0.033	0.114	0
A	5	2719.216**	13.823**	8.947**	1.600**	7.703**	0.002**
Ea	10	177.996	1.85	1.189	0.019	0.125	0
B	2	27361.24**	11.847**	154.984**	6.936**	19.598**	0.007**
AB	10	3556.504**	16.720**	1.470n.s	0.385**	3.346**	0.002**
Eb	24	143.414	1.222	0.95	0.019	0.146	0
Total	53						
Average of both locations							
SOV	**df**	***NO. of spike***	***No of grain /spike***	**1000grian weight**	**Grain yield (ton ha-1)**	**Biological yield (ton ha-1)**	**Harvest index**
Location	1	402112.3**	565.218**	3438.088**	199.728**	980.516**	0.101**
R/L	4	801.531	3.237	3.684	0.019	0.06	0
A	5	4955.658**	47.240**	32.923**	2.061**	9.102**	0.007**
A*L	5	3448.696	3.625	4.591	0.626	3.13	0.003
Ea	20	221.143	1.773	0.785	0.013	0.092	0
B	2	67209.69**	42.065**	214.669**	11.214**	54.609**	0.008**
B*L	2	2941.069	46.923	9.032	0.389	1.551	0.006
AB	10	2531.165**	9.160**	2.645**	0.262**	4.311**	0.003**
AB*L	10	3896.78	11.323	3.052	0.395	3.982	0.002
Eb	48	123.083	1.1	0.801	0.011	0.087	0
	107						