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Nitrogen Use Efficiency and Adaptation of Elite Varieties of Dryland Wheat (*Triticum aestivum* L.) in the Loess Plateau of China

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HIGHLIGHTS

- The yield of wheat cultivar yunhan-20410 was the highest.
- Water and nutrient are the main limiting factors of wheat production in dryland.
- Wheat varieties (YH20410, YH618, YH805, JM92, LH6 and C6359) with high yield.

Abstract: Wheat is the most widely cultivated food crop on the planet, and it feeds the majority of the world's population. The field experiment was performed from 2019 to 2021 in the eastern part of Loess Plateau, China Nitrogen (N) fertilizer application improves winter wheat yield. It was necessary to analyze the nitrogen utilization of different varieties and screen varieties with high yield and high nitrogen utilization. Six dryland wheat varieties YH-20410, YH-618, YH-805, JM-92, C-6359, and LH-6 were selected to compare the differences in nitrogen uptake and utilization yield, and quality. The aim was to provide theoretical basis for high yield, and high-efficiency wheat production in dryland of southeast loess Plateau. The results showed that the rainfall during the fallow period from 2019 to 2021 was 245.5 mm and 288.9 mm, respectively, and the nitrogen application rate was 180 kg ha^{-1}.The highest transshipment amount, and transshipment rate of nitrogen before anther were found in YH-618, which reached 79.4 kg ha^{-1} and 58.6%, respectively. The yield of wheat cultivar YH-20410 was the highest, reaching 4890 kg ha^{-1}, which was significantly higher than that of YH-805, JM-92, C-6359 and LH-6, but there was no significant difference of YH-618. The grain protein content of YH-618 was the highest (15.2%), which was not significantly different from that of JM-92, YH-805 and LH-6, but significantly higher than that of YH-20410, and C-6359, respectively. Therefore, in high-yield years, fallow cultivation can help adjust the relationship among the components, promote a reasonable distribution, and improve yield.

Keywords: Dryland wheat; Grain yield; Loess Plateau; Precipitation; Photosynthetic characteristics.

INTRODUCTION

Wheat (*Triticum aestivum* L.) is the third most grown crop globally and feeds about 30% of the world's population [1]. Winter wheat is one of the main food crops in the arid area of the Loess Plateau, accounting for 44% of the total cultivated land area in the northwestern China, and plays an important role in food security [2]. Precipitation in the arid area of the Loess Plateau is the sole water source for wheat production. The average annual rainfall is 501.6 mm over the last 30 years, and approximately 55% (275 mm) occurs in summer fallow from July to September, and evaporation in summer fallow is large. Approximately 45% (225 mm) of annual precipitation occurs during the winter wheat growth period. Inadequate and variable rainfall often results in inadequate soil water at sowing, leading to drought stress in the growing period. This is the main factor that results in low and unstable winter wheat yield [3].

Nitrogen is the material basis for the synthesis of wheat protein. Within a certain range, with the increase of nitrogen application level, the protein content of wheat grains increases, but excessive or insufficient nitrogen application will reduce the transport of accumulated nitrogen before anthesis to grains and affect the protein content of grains [4]. For farmers on the Loess Plateau, excessive pursuit of high yield and high quality wheat grains is one of the main reasons for excessive nitrogen application in dryland wheat fields [3, 4].

Scientific and reasonable fertilizer management in production will significantly reduce farmers' excessive input, but reducing nitrogen fertilizer application may reduce grain protein content of dryland wheat [4]. There were significant differences in nitrogen uptake, and utilization characteristics among wheat varieties with different genotypes, such as old varieties, local varieties, farmer's reserved varieties, and wild relatives [5]. Genetic effects of genes also have a significant influence on nitrogen absorption utilization, and protein content of wheat grains, and the main quality traits of wheat vary greatly among different varieties [6].

Under the condition of the same nitrogen application rate, climate environment has little influence on nitrogen absorption efficiency of different wheat varieties, but there is a large difference between varieties, which is called significant genotype effect [7].The Nanjing and Xuzhou there was little difference in N harvest index among varieties, and other indexes of N use efficiency were greatly affected by varieties, among which N absorption efficiency and N use efficiency were less affected by environment [8, 9]. The nitrogen efficient varieties had obvious advantages under the condition of low nitrogen, and could satisfy the nitrogen utilization of plants by reducing unnecessary nitrogen consumption.

There were also differences in nitrogen use efficiency of wheat varieties under the gradient of nitrogen application rate [10]. The 30 wheat varieties could be divided according to nitrogen use efficiency under the conditions of high and low soil fertility, and wheat varieties with the same level of N efficiency had different ways to achieve high nitrogen efficiency [11]. Due to differences between different varieties of nitrogen absorption use, will cause the entire plant reproductive period to the difference of nitrogen, so under the appropriate N application rate, according to the characteristics of the different varieties of nitrogen accumulation to use, can play the most optimal varieties nitrogen absorption efficiency, so as to keep production stable and improve the quality of the grain [12]. In the dryland farming wheat region of the Loess Plateau, varieties have always been numerous and mixed, and have been replaced for many times, with many high-yield and high-quality varieties emerging. Therefore, based on the screening results of dryland wheat varieties [13].The objective of this study was to carry out an extensive prospection of the wheat dryland cultivation of Shanxi Agriculture Wenxi. On the basis of nitrogen application by precipitation in fallow period, The comparative study on nitrogen utilization, yield and quality of wheat varieties in different dryland was carried out to provide theoretical basis and technical support for the cultivation and promotion of high-yield, high-quality and high-efficient wheat varieties in dryland.

MATERIAL AND METHODS

Experimental Site

The field experimental wheat base of Shanxi Agricultural Wenxi (35°20N, 111°17E) from 2019–2021, in Wenxi County, Shanxi Province, China. This region located in the eastern Loess Plateau, with an altitude of 450-700 m, annual sunshine of 2300 h, an average annual temperature of 12–14 °C, a frost-free period of about 200 d, and temperate continental monsoon climate. The experimental site was irrigated land with sufficient irrigation conditions, winter wheat and summer corn, planted per year. Winter wheat is planted from mid-late October to early mid-June of the following year, and corn is planted in late June and harvested in early October of the same year. The average precipitation during 2008–2018 was 202.1 mm in the growth seasons, and the total precipitation during the winter wheat growing seasons in 2019–2020 and 2020–2021 was 240.9 mm, and 218.3 mm, respectively. The basic soil fertility of the 0–20 cm soil layer before sowing in the two experimental years shown in Table 1.

Table 1. Basic chemical properties of the 0-20 cm soils at experiment site in Wenxi Shanxi

Index	pH	SOM (g kg^{-1})	Total N (g kg^{-1})	Ammonium N (mg kg^{-1})	Nitrate N (mg kg^{-1})	Phosphorus (mg kg^{-1})	Available K (mg kg^{-1})
0-10 cm	7.9	9.5	0.61	2.5	6.6	14.6	129
10-20 cm	8.1	10.3	0.66	3.3	10.3	19.6	150
0-20 cm	7.9	9.9	0.69	2.9	8.5	17.1	139.5

Table 2. Precipitation at the experimental site in Wenxi Shanxi 2019-2021

Year	Fallow season	Sowing-Wintering	Wintering-Jointing	Jointing – Anthesis	Anthesis – Maturity	Total
2019-2020	254.5	50.0	8.9	36.7	73.3	423.4
2020-2021	288.9	109.6	43.9	5.1	71.4	518.9

Experimental design

This experiment featured a single-factor randomized block design. Two Nitrogen fertilizer application (0, and 180 kg N ha^{-1}). The experiment was arranged in Wenxi Test Base, Yuncheng City, Shanxi Province from 2019 to 2021. Six wheat varieties yunhan-20410 (YH-20410), Yunhan-618 (YH-618), Chang-6359 (C-6359), Yunhan-805 (YH-805), Luohan-6 (LH-6) and Jinmai-92 (JM-92) were set up in dryland. Plot size was 6 m × 50 m, and each treatment was replicated three times. Provided by Agriculture and Rural Bureau of Wenxi County, Shanxi Province, was used with a sowing amount of 225 kg ha^{-1}. Before sowing, the land was rotated-tillage, P_2O_5 150 kg ha^{-1}, and K_2O 90 kg ha^{-1} were applied. Nitrogen fertilizer was applied at 6:4 before sowing and at the jointing stage, and irrigation was 60 mm at the jointing stage. Sowing was carried out on October 9 and 25 in the two years, and the sowing method was wide-space sowing. Wheat was harvested on June 7 and June 10. The field management was routine. The main information experimental site was located in shown in Figure 1. "One spray for controlling three problems" was also applied at anthesis stage, which was a combination of pesticides, fungicides, plant growth regulators, and micro fertilizer, to prevent diseases, insects, and premature plant aging. No irrigation was applied during the whole experiment.

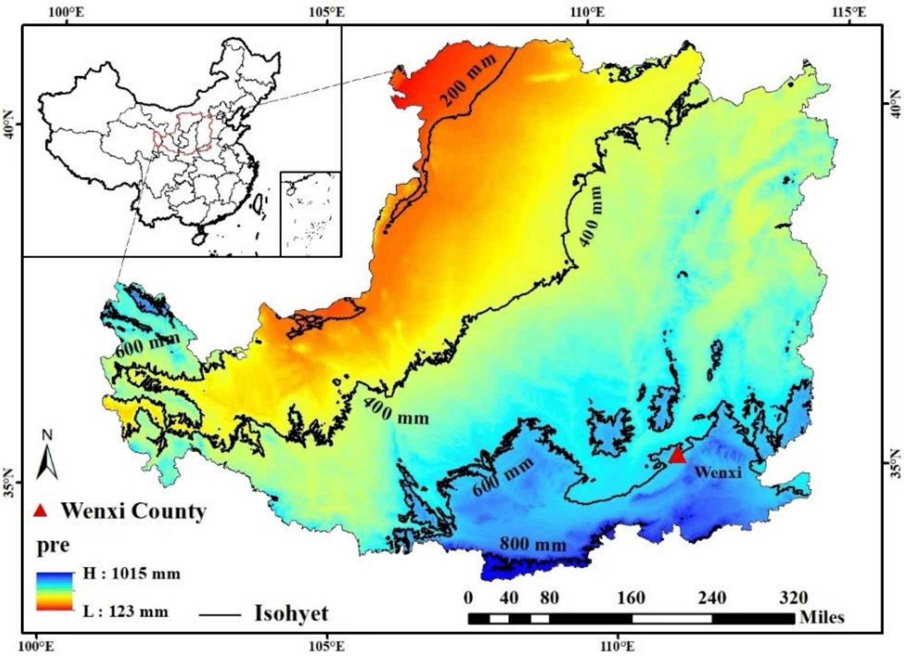

Figure 1. Location of experiment site in the Loess Plateau. The regional distribution of annual precipitation is shown in different colors on the map.

Measurements

Photosynthetic characteristics, functional nitrogen storage:

Photosynthetic characteristics is considered to be the essential nitrogen of photoreceptor chlorophyll and various photosynthetic coenzymes in various organs of plants involved in photosynthesis. Such nitrogen not only participates in photosynthesis, but also is transferred from photosynthetic organs to grains at the filling stage [14].

Functional N = structural N + photosynthetic N.

Stored nitrogen is not directly involved in plant physiological metabolism, but only stored in plant organs. When grain filling starts, nitrogen is directly transported to the grain [14].

Stored Nitrogen = organ nitrogen accumulation functional nitrogen. At present, it is impossible to accurately calculate photosynthetic nitrogen. Only by estimating functional nitrogen and structural nitrogen can photosynthetic characteristics nitrogen be calculated [14].

Tiller population and aboveground dry matter

At the three-leaf stage of winter wheat, three rows of sample sections with a uniform growth area of 0.667 m^2 were selected to investigate the basic seedlings. The number of tillers was investigated in the sample sections at the wintering, jointing, booting, and anthesis stages. Twenty plants were randomly sampled from each community at the jointing, anthesis, and maturity stages of winter wheat, and the jointing stage is the whole plant; the anthesis stage is divided into three parts: leaf, stem + sheath, and spike, and the maturity stage is divided into four parts: leaf, stem + sheath, glume + spike, and grain. The grains were baked to a constant weight at 65 °C, and the other organs were baked to a constant weight at 75 °C for 30 min at 105 °C. Weights were recorded, and the related calculations of dry matter weight were combined with basic seedlings.

Grain Yield and Yield Component

At maturity, 20 plants from each plot were randomly sampled from the inner rows to determine yield components such as ear number, grain number per ear and 1,000-grain weight. Grain yield was obtained by harvesting all plants in the plot.

Estimation method of functional nitrogen

From the root to the flowering period and the dry land wheat leaf area and leaf nitrogen accumulation increased gradually, the group light energy use efficiency are also gradually increase, when the group reached maximum light energy use efficiency, leaf nitrogen accumulation just is the sum of nitrogen and photosynthetic structure, namely the function of nitrogen, then light energy use efficiency than leaf nitrogen increase no longer increases, Since then, stored nitrogen has increased [14].

Statistical analysis

Experimental statistics was statistically examined by Microsoft Excel 2016 and Statistix 8.0 (Analytical Software, FL, Tallahassee, USA), and the figure was produced using Origin Lab pro 2021b (OriginLab Corporation, Northamptn, MA, USA). Comparisons among numerous groups were achieved using Tukey's honestly significant difference (HSD) test. Possibility values $p < 0.05$ were measured statistically significant. Statistix 8.0 software was used for alteration analysis.

RESULTS

Differences of varieties nitrogen accumulation in plants

Differences of variety YH-20410 had the highest average nitrogen accumulation at anthesis, reaching 141.8 kg ha^{-1}, but there was no significant difference with other cultivars. At two-year average maturity stage, YH-20410 had the highest nitrogen accumulation, up to 176.7 kg ha^{-1}, but there was no significant difference with other varieties (Figure 2A, B). The two-year average nitrogen accumulation in YH-618 was significantly the highest, reaching 118.2 kg ha^{-1} (Figure 2C). The two-year average N harvest index of YH-618 was significantly highest, reaching 0.70 (Figure 2D). The YH-618 had a higher proportion of nitrogen transport to grains.

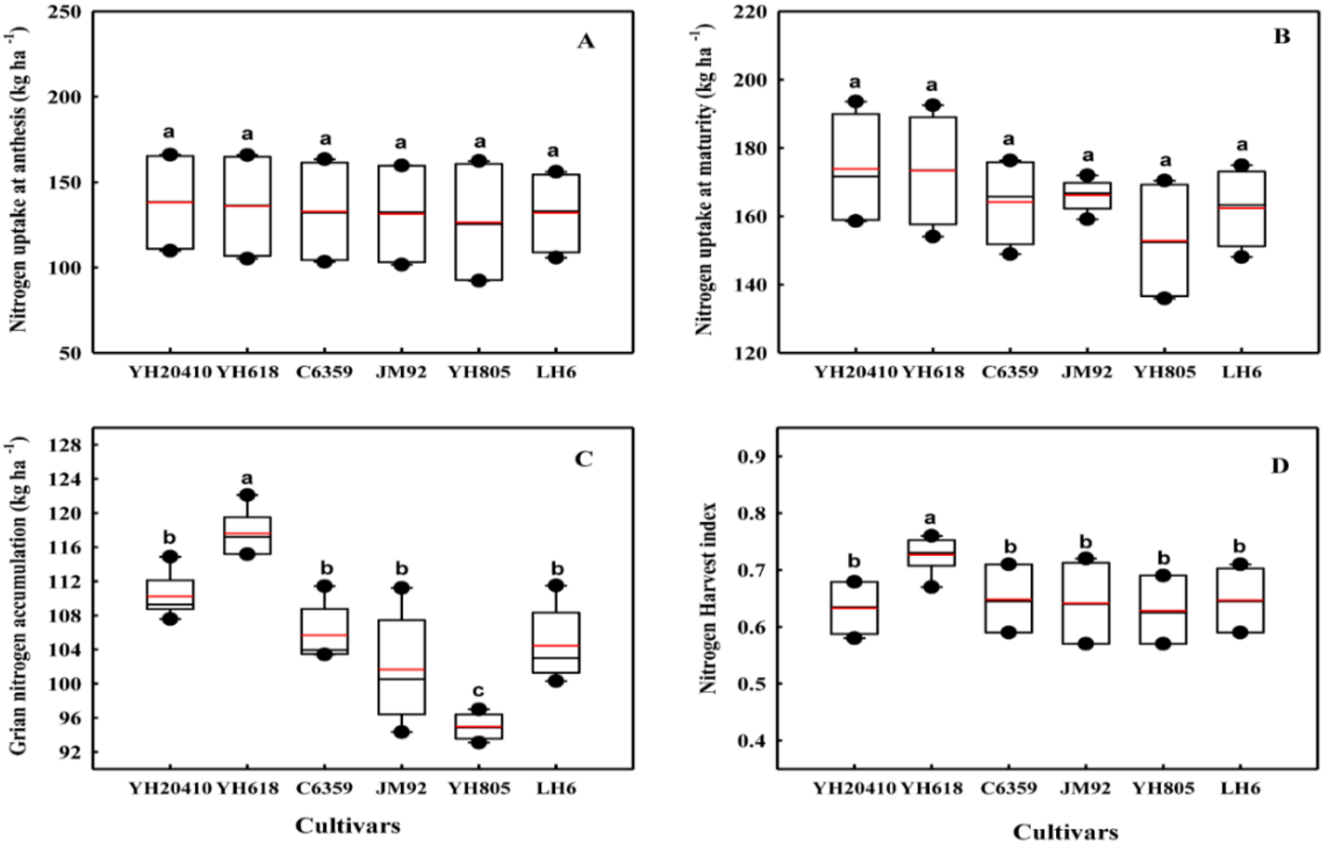

Figure 2. Difference of varieties anthesis, and maturity stage, grain N accumulation in dryland wheat. (**A**) Nitrogen uptake at anthesis. (**B**) Nitrogen uptake at maturity. (**C**) Grain nitrogen accumulation. (**D**) Nitrogen harvest index. All data represent means ± standard errors of three replicates. Values with different letters on the same sampling day indicate significant differences at *P*<0.05.

The two-year mean spike number of YH-20410 was the highest, reaching 409.5×104 kg ha^{-1}, but there was no significant difference with other varieties (Figure 3A). The average grain number per spike in two years was 37.9 in YH-20410, which was significantly different from other varieties except YH-618 (Figure 3B). The average 1000-grain weight of YH-20140 was the highest (40.8 g), which was significantly higher than that of YH-805 and LH-6, but not significantly different from that of YH-618, C-6359, and JM-92 (Figure 3C). The main reason for the higher yield of YH-20410, and YH-618 compared with other varieties was the higher grain number per spike.

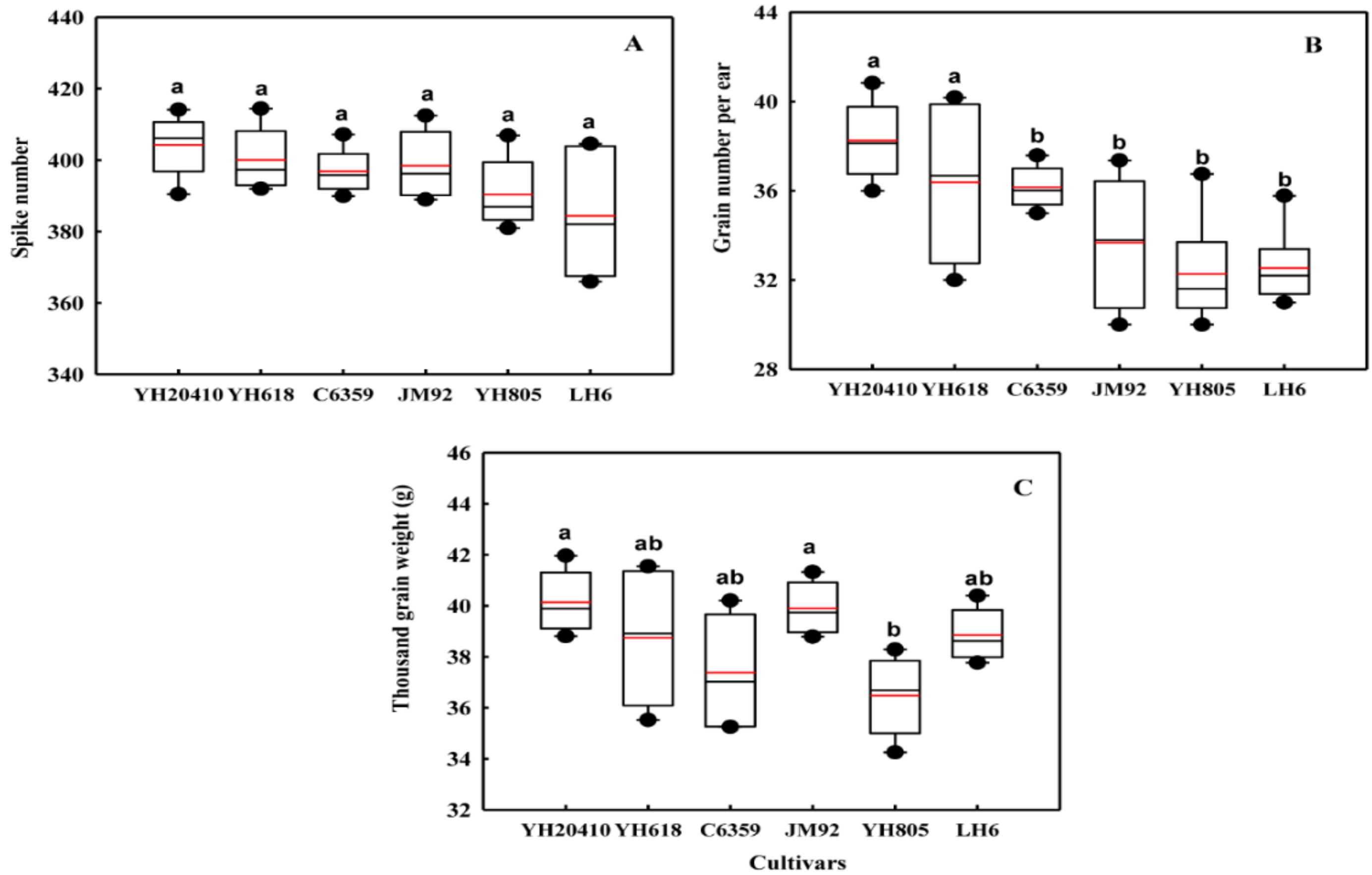

Figure 3. Difference of varieties grain yield components between dryland wheat cultivars. (**A**) Spike number (**B**) Grain number per ear (**C**) Thousand grain weight. All data represent means ± standard errors of three replicates. Values with different letters on the same sampling day indicate significant differences at *P*<0.05.

Differences of varieties grain protein content among in dryland wheat

The grain protein content of C-6359 was significantly the highest (15.9%), followed by YH-618 (15.2%), YH-805, LH-6, JM-92 and YH-20410 were the lowest, and YH-20410 was 14.2%. In 2019-2020, the grain protein content of LH-6 was the highest, reaching 15.4%, which was significantly different from other varieties except YH-618. The two-year average grain protein content of YH-618 was the highest (15.2%), which was significantly different from other varieties except JM-92, YH-805 and LH-6 (Figure 4a). The protein content of YH-618 grains is higher, reaching 15.2% (Figure 4b). From 2018 to 2019, the grain nitrogen concentration was significantly higher in C-6359, which reached 25.4 g kg^{-1}.From 2019 to 2020, the grain nitrogen concentration of LH-6 was significantly the highest, reaching 24.7 g kg^{-1}.The average nitrogen concentration of YH-618 was 24.4 g kg^{-1}, which was significantly different from that of YH-20410, but not significantly different from that of JM-92, C-6359, YH-805, and LH-6.

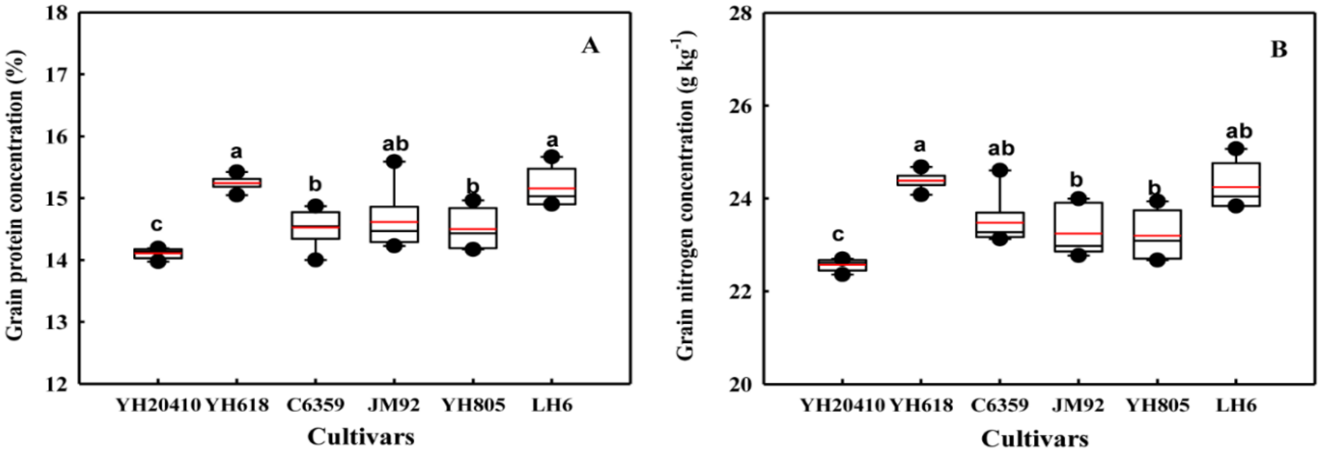

Figure 4. Difference of varieties grain protein concentration and N concentration between in dryland wheat. (**A**) Grain protein concentration (**B**) Grain nitrogen concentration. All data represent means ± standard errors of three replicates. Values with different letters on the same sampling day indicate significant differences at *P*<0.05.

Differences of Photosynthetic characteristics Reserve N, and transport in plants in dryland wheat

The YH-805 had the highest photosynthetic nitrogen content (38.25 kg ha^{-1}), and YH-20410 had the lowest photosynthetic nitrogen content (31.21 kg ha^{-1}) (Table 3). There was no significant difference in photosynthetic nitrogen content between YH-618, JM-92, C-6359 and LH-6, which was about 34.63-36.37 kg ha^{-1}. In 2019-2020, YH-805 had the highest photosynthetic nitrogen content, reaching 54.46 kg ha^{-1}, which was significantly different from other varieties except LH-6. The average photosynthetic nitrogen in YH-805 was the highest, reaching 46.36 kg ha^{-1}. The photosynthetic nitrogen content of YH-618 was 43.33 kg ha^{-1}, which was significantly higher than that of YH-20410. The photosynthetic nitrogen of YH-805 was the highest, and that of YH-618 was higher than that of YH-20410. In 2018-2019, YH-805 had the highest photosynthetic nitrogen content (38.25 kg ha^{-1}), and YH-20410 had the lowest photosynthetic nitrogen content (31.21 kg ha^{-1}).There was no significant difference in photosynthetic nitrogen content between YH-618, JM-92, C-6359 and LH-6, which was about 34.63-36.37 kg ha^{-1}.In 2019-2020, YH-805 had the highest photosynthetic nitrogen content, reaching 54.46 kg ha^{-1}, which was significantly different from other varieties except YH-6. The average photosynthetic nitrogen in YH-805 was the highest, reaching 46.36 kg ha^{-1}. The photosynthetic nitrogen content of YH-618 was 43.33 kg ha^{-1}, which was significantly higher than that of YH-20410. It can be seen that the (Table 3). Photosynthetic nitrogen of YH-805 was the highest, and that of YH-618 was higher than that of YH-20410. Nitrogen storage from 2018 to 2019, LH-6 had the highest nitrogen storage amount (35.03 kg ha^{-1}), which was significantly different from other varieties except YH-20410. In 2019-2020, YH-20410 was the highest, reaching 53.79 kg ha^{-1}, which was significantly different from other varieties except YH-618. Stored nitrogen of YH-20410, and YH-618 was higher than that of other varieties. The transshipment of nitrogen in YH-618 was significantly the highest, reaching 63.65 kg ha^{-1}. The transshipment of nitrogen in YH-618 was significantly the highest, reaching 95.18 kg ha^{-1} (Table 4). The average nitrogen transfer rate before flowering was 58.61% in YH-618. The average nitrogen uptake after anthesis was significantly higher in YH-20410, which reached 25.2 kg ha^{-1}. In conclusion, the higher nitrogen translocation and nitrogen translocation rate before anthesis were the main reasons for the higher grain protein content of YH-618.

Table 3. Differences of cultivars Remobilized part of Photosynthetic characteristics N and Reserve N in dryland wheat.

Year	Cultivar	Photosynthetic characteristics (kg ha^{-1})						Reserve N (kg ha^{-1})					
		Residual part			Remobilised part			Residual part			Remobilised part		
		Leaf	Stem + Leaf sheath Stem+ sheaths	Spike	Leaf	Stem + Leaf sheath Stem+ sheaths	Spike	Leaf	Stem + Leaf sheath Stem+ sheaths	Spike	Leaf	Stem + Leaf sheath Stem+ sheaths	Spike
2019-2020	YH-20410	3.17	7.59	1.00	19.53	6.97	0.54	0.00	0.00	0.00	7.06	13.54	14.28
	YH-618	0.00	3.91	0.70	22.76	11.35	3.83	0.00	0.00	0.00	9.08	13.89	16.95
	C-6359	0.00	4.83	0.52	21.45	11.34	2.25	0.00	0.00	0.00	5.94	12.18	10.23
	JM-92	0.09	6.45	0.54	21.60	11.85	2.30	0.00	0.00	0.00	5.71	10.85	10.60
	YH-805	6.53	0.41	1.32	22.51	5.59	2.30	0.00	0.00	0.00	5.58	13.33	7.89
	LH-6	0.00	8.28	1.55	21.57	10.46	1.87	0.00	0.00	0.00	7.45	18.52	9.06
	Mean	**1.63**	**5.24**	**0.94**	**21.24**	**9.59**	**1.85**	**0.00**	**0.00**	**0.00**	**6.47**	**13.38**	**10.67**
2020-2021	YH-20410	4.24	9.68	2.83	19.81	16.98	0.00	0.00	0.00	6.12	20.57	11.79	18.31
	YH-618	2.23	3.35	1.87	22.42	24.16	0.00	0.00	0.00	2.60	22.26	14.52	13.82
	C-6359	3.27	3.55	1.80	18.94	22.77	0.00	0.00	0.00	2.64	20.23	13.82	12.84
	JM-92	5.66	3.39	2.07	17.33	24.29	0.00	0.00	0.00	2.35	20.55	13.13	12.26
	YH-805	6.07	3.92	3.11	17.77	23.59	0.00	0.00	0.00	2.77	20.77	15.32	9.99
	LH-6	3.45	4.54	3.30	20.86	21.99	0.00	0.00	0.00	2.54	15.55	15.19	9.37
	Mean	**3.82**	**4.74**	**2.17**	**19.19**	**22.30**	**0.00**	**0.00**	**0.00**	**2.67**	**19.99**	**13.96**	**12.77**
Mean	YH-20410	2.71	8.64	1.91	19.67	11.98	0.27	0.00	0.00	3.56	13.82	12.67	7.14
	YH-618	1.12	3.63	1.29	22.59	17.76	1.91	0.00	0.00	1.30	15.67	14.21	8.47
	C-6359	1.64	4.19	1.16	20.20	17.05	1.12	0.00	0.00	1.32	13.08	13.00	5.12
	JM-92	2.88	4.92	1.30	19.46	18.07	1.15	0.00	0.00	1.17	13.13	11.99	5.30
	YH-805	6.30	2.16	2.22	20.14	14.59	1.15	0.00	0.00	1.38	13.17	14.32	3.94
	LH-6	1.73	6.41	2.43	21.22	16.22	0.93	0.00	0.00	1.27	11.50	16.85	4.53
	Mean	**2.73**	**4.99**	**1.55**	**20.21**	**15.94**	**0.92**	**0.00**	**0.00**	**1.33**	**13.23**	**13.67**	**5.33**
ANOVA													
C		*	*	*	*	*	*	*	*	*	*	*	*
Y		*	*	*	*	*	*	*	*	*	*	*	*
C×Y		ns	ns	ns	ns	ns	ns	*	ns	ns	ns	ns	ns

Table 4. Differences of cultivars N absorption and N remobilized in dryland wheat.

Year	Cultivar	N absorption (kg ha^{-1})	N remobilized (kg ha^{-1})				N Remobilised rate (%)			
			Leaf	Stem + sheaths	Spike + glume	Total	Leaf	Stem + sheaths	Spike + glume	Total
2019-2020	YH-	24.88 ^{b}	26.18 ^{a}	20.51 ^{d}	14.82 ^{a}	61.52 ^{b}	55.39 ^{a}	51.58 ^{e}	61.19 ^{b}	55.29 ^{c}
	YH-618	29.35 ^{a}	23.93 ^{b}	25.94 ^{b}	13.78 ^{b}	63.65 ^{a}	50.60 ^{b}	68.07 ^{a}	62.93 ^{a}	59.32 ^{a}
	C-6359	18.85 ^{d}	22.55 ^{c}	24.77 ^{b}	12.48 ^{c}	59.81 ^{c}	48.88 ^{c}	64.51 ^{b}	61.88 ^{a}	57.11 ^{b}
	JM-92	29.67 ^{a}	20.85 ^{d}	22.70 ^{c}	12.90 ^{c}	56.45 ^{d}	45.42 ^{d}	61.21 ^{c}	62.80 ^{a}	54.52 ^{c}
	YH-805	23.21 ^{b}	20.50 ^{d}	18.92 ^{e}	10.19 ^{d}	49.61 ^{e}	50.26 ^{b}	55.55 ^{d}	57.14 ^{d}	53.53 ^{c}
	LH-6	20.15 ^{c}	20.74 ^{d}	33.27 ^{a}	10.93 ^{d}	64.94 ^{a}	44.93 ^{d}	74.36 ^{a}	57.51 ^{c}	59.09 ^{a}
	Mean	**24.35**	**22.46**	**24.35**	**12.52**	**59.33**	**49.25**	**62.55**	**60.57**	**56.48**
2020-2021	YH-	25.47 ^{a}	40.38 ^{b}	28.78 ^{c}	18.31 ^{a}	87.47 ^{b}	56.22 ^{b}	47.04 ^{c}	57.21 ^{a}	53.01 ^{b}
	YH-618	9.84 ^{b}	42.68 ^{a}	38.68 ^{a}	13.82 ^{b}	95.18 ^{a}	58.05 ^{a}	60.53 ^{a}	51.19 ^{b}	57.89 ^{a}
	C-6359	10.89 ^{b}	39.17 ^{b}	36.58 ^{b}	12.84 ^{b}	88.60 ^{b}	54.79 ^{b}	57.89 ^{b}	49.28 ^{b}	55.12 ^{b}
	JM-92	5.56 ^{c}	37.88 ^{c}	37.42 ^{b}	12.26 ^{b}	87.55 ^{b}	52.75 ^{c}	59.86 ^{b}	48.67 ^{b}	54.89 ^{b}
	YH-805	4.81 ^{c}	38.53 ^{b}	38.91 ^{a}	9.99 ^{c}	87.44 ^{b}	53.50 ^{c}	60.14 ^{a}	42.82 ^{c}	54.63 ^{b}
	LH-6	14.76 ^{b}	36.41 ^{c}	37.17 ^{b}	9.37 ^{c}	82.94 ^{b}	54.49 ^{b}	57.57 ^{b}	41.65 ^{c}	53.91 ^{b}
	Mean	**11.89**	**39.17 ^{a}**	**36.26 ^{a}**	**12.77**	**88.21**	**54.97**	**57.17**	**48.47**	**54.91**
Mean	YH-	25.18 ^{a}	33.28 ^{b}	24.64 ^{d}	16.57 ^{a}	74.49 ^{b}	55.81 ^{a}	49.31 ^{d}	59.21 ^{a}	54.15 ^{c}
	YH-618	19.61 ^{b}	33.31 ^{b}	32.31 ^{b}	13.81 ^{b}	79.42 ^{a}	54.33 ^{a}	64.31 ^{a}	57.06 ^{b}	58.61 ^{a}
	C-6359	14.87 ^{c}	30.86 ^{c}	30.68 ^{b}	12.66 ^{c}	74.21 ^{b}	51.84 ^{b}	61.21 ^{b}	55.58 ^{c}	56.11 ^{b}
	JM-92	17.61 ^{b}	29.36 ^{c}	30.06 ^{b}	12.58 ^{c}	72.01 ^{c}	49.08 ^{b}	60.54 ^{b}	55.73 ^{c}	54.71 ^{c}
	YH-805	14.01 ^{c}	29.52 ^{c}	28.91 ^{c}	10.09 ^{d}	68.52 ^{d}	51.88 ^{b}	57.85 ^{c}	49.98 ^{d}	54.08 ^{c}
	LH-6	17.45 ^{b}	28.57 ^{c}	35.22 ^{a}	10.15 ^{d}	73.94 ^{c}	49.71 ^{b}	65.96 ^{a}	49.58 ^{d}	56.50 ^{b}
	Mean	**18.12**	**30.82**	**30.31**	**12.64**	**73.76**	**52.11**	**59.86**	**54.52**	**55.69**
ANOVA										
C		*	*	*	*	*	*	*	*	*
Y		*	*	*	*	*	*	*	*	*
C×Y		ns	ns	ns	ns	ns	*	ns	ns	*

Note: N absorption indicates the plant nitrogen absorption amount during the anthesis to maturity.

Table 5. Differences of cultivars grain yield and its components in dryland wheat.

Year	N rate	Cultivar	Spike number ($\times 10^4$ ha^{-1})	Grains per spike	1000-grains weight (g)	Yield (t ha^{-1})
2019-2020	N0	YH-20410	335.30 a	36.30 a	32.90 b	3.32 a
		YH-618	317.20 b	36.40 a	28.80 c	2.78 c
		C-6359	313.80 b	33.10 b	27.70 d	2.42 e
		JM-92	324.10 a	33.40 b	32.40 b	2.93 b
		YH-805	316.80 b	33.30 b	29.10 c	2.57 d
		LH-6	305.40 c	33.10 b	34.70 a	2.91 b
		Mean	**318.8**	**34.3**	**30.9**	**2.82**
	N180	YH-20410	399.0 a	38.80 b	38.10 b	4.82 a
		YH-618	399.0 a	39.80 a	36.30 c	4.72 b
		C-6359	397.3 a	36.80 c	35.30 c	4.25 d
		JM-92	390.5 b	37.40 c	39.00 ab	4.66 b
		YH-805	384.0 d	37.20 c	35.20 b	4.13 e
		LH-6	368.0 e	36.60 c	41.10 a	4.50 c
		Mean	**389.6**	**37.8**	**37.5**	**4.51**
2020-2021	N0	YH-20410	354.10 a	34.60 a	34.3 a	3.50 a
		YH-618	305.70 d	30.20 b	33.8 a	2.63 b
		C-6359	306.10 d	32.00 b	31.0 b	2.52 c
		JM-92	337.20 c	27.80 c	33.9 a	2.67 b
		YH-805	343.90 b	27.80 c	31.1 b	2.52 c
		LH-6	349.90 ab	28.50 c	33.10 ab	2.72 b
		Mean	**332.8**	**30.1**	**32.9**	**2.76**
	N180	YH-20410	409.50 a	37.0 a	39.70 b	4.95 a
		YH-618	384.50 c	35.0 b	42.60 a	4.91 a
		C-6359	390.00 b	35.5 bc	39.50 b	4.46 b
		JM-92	406.50 ab	31.0 c	40.80 b	4.24 c
		YH-805	416.90 a	31.0 c	37.70 c	4.06 e
		LH-6	414.20 a	31.5 c	39.20 b	4.12 d
		Mean	**403.6**	**33.2**	**39.9**	**4.45**

Cont. Table 5

ANOVA				
C	*	*	*	*
Y	*	*	*	*
N	*	*	*	*
C×Y	ns	ns	ns	ns
Y×N	*	ns	*	*
C×N	*	*	ns	ns
C×Y×N	ns	ns	ns	ns

The two-year mean spike number of YH-20410 was the highest, reaching 409.5×104 kg ha^{-1}, but there was no significant difference with other varieties (Table 5). The average grain number per spike in two years was 37.9 in YH-20410, which was significantly different from other varieties except YH-618. The average 1000-grain weight of YH-20140 was the highest (40.8 g), which was significantly higher than that of YH-805 and LH-6, but not significantly different from that of YH-618, C-6359, and JM-92. The main reason for the higher yield of YH-20410, and YH-618 compared to other varieties was the higher grain number per spike.

DISCUSSION

Effects of differences varieties structural nitrogen in dryland wheat

Even for superior wheat varieties, the proportion of nitrogen fertilizer available is limited, typically 50-60% of winter wheat [15.16]. Large amount of nitrogen will be lost to the environment, which is a considerable cost loss for farmers and has an impact on the environment soil nitrogen is easily leaching [17]. Denitrified with nitrate by soil bacteria or nitrified with ammonium nitrogen to discharge N_2O [18, 19]. Considering the importance of nitrogen to crop growth and development, Nitrogen is arguably the most restrictive and important nutrient required by crops [20]. Therefore, more and more attention has been paid to the cultivation of wheat varieties with high nitrogen efficiency [21, 22].The increase of pre-flowering nitrogen supply was mainly through increasing canopy green leaf area of crops [23, 24]. Rather than increasing photosynthetic rate, thus improving light energy interception and dry matter mass [25]. Part of nitrate, and ammonium salts absorbed by crop roots are used to participate in the synthesis of photosynthetic, and the other part is used to participate in the synthesis of structural protein tissues in the vascular system [26]. Therefore, nitrogen involved in the synthesis of photosynthetic characteristics tissue can be considered as photosynthetic characteristics in functional concept, while nitrogen involved in the synthesis of vascular structural protein tissue can be considered as structural nitrogen in functional concept, while other nitrogen not allocated to the above pathway can be considered as storage nitrogen [27]. Agronomic efficiency corresponds to an increase in yield per unit of applied nutrients. The Agronomic efficiency nitrogen measured in our study ranged from 22.1 to 26.4 kg kg^{-1} with the mean value of 24.3 kg grains kg N^{-1} is lower than the value (36.6 kg kg^{-1}) recorded by [28]. The wheat plant can utilize most of the N supplied for grain production at the lower rate. Agronomic efficiency nitrogen was substantially reduced in the highest N fertilizer level, which is similar to the data recorded by various researchers [29]. The nitrogen accumulation in winter wheat under high N supply significantly exceeds the estimated sum of structural N and photosynthetic characteristics [30]. Showed that, under high nitrogen supply, the accumulation of above-ground nitrogen in winter wheat was as high as 5.1 kg ha^{-1}, which was more than 60% higher than the critical nitrogen concentration, indicating a high proportion of stored nitrogen in plants [31].Therefore, quantitative analysis of structural nitrogen, "photosynthetic characteristics, and nitrogen is of great significance for determining nitrogen accumulation and translocation in wheat plants. The results showed that compared to other in dryland wheat varieties, Yunhan-20410 had higher structural nitrogen (53.42 kg ha^{-1} on average), and Yunhan-618 had a higher structural nitrogen (50.47 kg ha^{-1}), indicating that Yunhan-20410 had a higher structural nitrogen than other wheat varieties. There is a close relationship between the nitrogen status of wheat, and the size of canopy green leaf area and the light energy use efficiency [32].The increase of specific leaf N, the light use efficiency in dryland wheat showed a linear + plateau trend, and when the specific leaf nitrogen increased to 1.55 kg ha^{-1}, the light use efficiency reached the plateau value of 2.165 g^{-1}. The nitrogen of wheat cultivar population gradually accumulated in dryland, and the light use efficiency increased continuously. When specific leaf nitrogen reached 1.55 kg ha^{-1}, the light use efficiency of wheat reached the maximum, but the nitrogen accumulation of plant continued, and the accumulated nitrogen was stored nitrogen. This is 0.45 kg ha^{-1} lower than the results of [33]. The process of nitrogen transport from wheat organs to grains is extremely complex in physiology. Field-scale studies have no way to determine which photosynthetic characteristics, and stored nitrogen transport starts first, or even synchronously, but the transport ratio of photosynthetic characteristics, and stored nitrogen can be calculated [34]. Studies have shown that premature photosynthetic characteristics transport in wheat results in premature canopy leaf senescence, and grain yield reduction [35].Other studies have shown that nitrogen transport in leaves is controlled by genes, and nitrogen transport is directly regulated by genes related to leaf senescence [36].Therefore, it is of great significance to clarify the transport timing and proportion of "photosynthetic nitrogen [37]. The stored nitrogen of all in dryland wheat varieties could not meet the requirements of nitrogen transport of crops, and photosynthetic characteristics transport was carried out, and the average photosynthetic characteristics transport rate was 87.5% on June 18, which was significantly higher than that of 20410 (69.5%). The average transfer rate of stored nitrogen was 97.5%, which was higher than that of 20410 (94.5%). These results indicated that the translocation rate of photosynthetic characteristics, and storage nitrogen in Yunhan-20410 was relatively higher, while the translocation rate of photosynthetic characteristics, and storage nitrogen in Yunhan-618 was more active, so as to obtain higher protein content in grains. Resulting in lower upper limit of nitrogen accumulation in dryland wheat canopy. Compared to yunhan-20410, yunhan-618 had significantly higher photosynthetic characteristics (43.33 kg ha^{-1}), but no significant difference in stored nitrogen (42-44 kg ha^{-1}). Meanwhile, yunhan-618 had less structural nitrogen, which provided conditions for higher protein accumulation.

Effects of differences yield and varieties in dryland wheat

Since the 1980s, grain yield of wheat has been greatly improved worldwide [38]. Among all the means to promote wheat grain yield, the most important is the gradual selection and improvement of wheat varieties [39]. There are many varieties, and various varieties in dryland wheat region of loess Plateau, and highest yield, and high quality have been successfully bred and promoted [40]. Based on the preliminary screening results of six in dryland wheat varieties including Yunhan-20410, Yunhan-618, Yunhan-805, Jinmai-92, Chang-6359, and Luohan-6 were selected. On the basis of precipitation nitrogen application in fallow period, the differences of nitrogen absorption and utilization, yield and quality formation of different in dryland wheat varieties and their mechanisms were compared in order to select suitable in dryland wheat varieties with this nitrogen application method and provide theoretical basis for high yield and quality in dryland wheat. The wheat yield of Yunhan-20410 was significantly the highest, reaching 4.82 t ha^{-1}, followed by Yunhan-618, reaching 4.72 t ha^{-1}. In 2020-2021, yunhan-20410 had the highest yield of 4.95 t ha^{-1}, which was not significantly different from Yunhan-618, but significantly higher than other wheat varieties. The average yield of yunhan-20410 and Yunhan-618 in two years was higher than that of other varieties, but the difference was not significant. Studies post-anthracite grain filling capacity of wheat has a more direct influence on the formation of 1000-grain weight, and yield [41]. Different nitrogen rate compared to 1000-grain weight of wheat variety, the number of grains per unit area has a higher stability and heritability [42, 43]. Therefore, grain yield is more closely related to total grain number per unit area rather than 1000-grain weight [44, 45]. The results showed that the yield of Yunhan-20410 (4.89 t ha^{-1}) was not significantly different from that of Yunhan-618 (4.82 t ha^{-1}), but was significantly higher than that of Chang-6359, Jinmai-92, Luohan-6, and Yunhan-805. There was no significant difference in grain number per spike between Yunhan-20410 (37.9) and Yunhan-618 (37.4), but they were significantly higher than the other four varieties [46, 47]. The total number of grains per unit area was closely related to yield. The high-yielding varieties Yunhan-20410, and Yunhan-618 both had higher total number of grains per unit area. Protein content is the most important nutritional quality trait of wheat grains, and protein content of grains is closely related to processing quality [48]. Protein content is generally used to evaluate the grain, and flour quality of wheat. If protein content is high, wheat has better bread baking quality [49, 50]. According to the definition standards of protein content of strong, medium and weak gluten wheat in China protein content ≥14%, ≥13% and < 13% were defined as strong, medium and weak gluten wheat. The definition criteria of high quality strong ribs and high quality weak ribs are ≥15%, and ≤11.5% respectively [50]. The results showed that the protein content of Yunhan-20410 (14.1%) was significantly lower than that of Yunhan-618 (15.2%), Jinmai-92 (14.6%), Yunhan-805 (14.6%), and Luohan-6 (15.1%).The grain protein content of Yunhan-618 could meet the standard of high quality strong gluten, and the yield performance of yunhan-20410 was not significantly different from that of high yield variety.

CONCLUSION

Knowledge of the appropriate fertilizer rate and crop nutrient requirements is critical for farmers to enhance crop yields and nutrient use efficiency. The highest transshipment amount and transshipment rate of nitrogen before anther were found in Yunhan-618, which reached 79.4 kg ha^{-1} and 58.6%, respectively. The yield of wheat cultivar Yunhan-20410 was the highest, reaching 4890 kg ha^{-1}, which was significantly higher than that of Yunhan-805, Jinmai-92, Chang-6359 and Luohan-6, but there was no significant difference with That of Yunhan-618. The grain protein content of Yunhan-618 was the highest (15.2%), which was not significantly different from that of Jinmai-92, Yunhan-805 and Luohan-6, but significantly higher than that of Yunhan-20410 and Chang-6359. The highest N use efficiency and N uptake efficiency were found in Yunhan-618, which reached 11.6 kg kg^{-1}, and 0.61 kg kg^{-1}, respectively. Therefore, nitrogen application rate was determined according to the precipitation in the fallow period, and nitrogen application rate was 180 kg ha^{-1} in the whole year, and the yield and quality could be improved synchronously by selecting the cultivar Yunhan-618.

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