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Research Article

GENETIC VARIABILITY FOR NITROGEN USE EFFICIENCY (NUE) AND YIELD ATTRIBUTING TRAITS IN WHEAT

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Abstract- An experiment was conducted to study the genetic variability, heritability and expected genetic advance for morpho-physiological, yield and NUE component traits in wheat accession under two different N levels. A set of 84 wheat genotypes was evaluated at two different nitrogen regimes, the T0 (without an external supply of nitrogen) and T1 (100 kg N/ha, RDF). All the characters studied, have shown good amount of variability in the genotypes. The mean performance of physiological traits like NDVI and SPAD, yield related traits like the number of tillers per meter row, spikelet's per spike, spike length (cm), thousand grain weight (g) and seed yield (q/ha) and nitrogen use efficient traits like grain N, straw N, nitrogen uptake efficiency (NUpE) was found to be higher under the treatment with external supply of nitrogen (T1) than under the nitrogen stress treatment (T0). The high PCV and GCV values were recorded for trait grain yield, biomass and NUE, which indicates that, these characters have high variability that in turn offers good scope for selection. The high heritability estimates along with high genetic advance was obtained for NDVI at anthesis stage, days to fifty percent flowering, spike length, grain yield, biomass, harvest index (%), straw N, NUtE, NUpE and NUE. These traits are the most important to be taken into consideration for effective selection in wheat for NUE. Based on the four key variables determining N-efficiency in a wheat crop are grains N, NHI, high grain yield and high nitrogen use efficiency can be considered as important criteria for selection of high NUE in wheat. The genotypes *viz.,* 2nd WYCYT 34, 3 rd SATYN 9403, 5th CISA HTEM 10212 and WH 1022, were found showed the highest performance for these characteristics at both T0 and T1 nitrogen levels. These identified lines would be further used in development of nitrogen use efficient wheat varieties, which will greatly facilitate the resource poor farmers to enhance the productivity.

Keywords- Morpho- physiological, NUE, NUpE, NUtE and grain yield

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Introduction

In India, wheat is the most important cereal crop and plays an important role in food and nutritional security. Nitrogen (N) fertilizer is immensely required for enhancing food production. Reports till now indicate nitrogen use efficiency (NUE) in wheat is around 40-50%, which is leading to loss of more than 50 % of applied fertilizer nitrogen into environment and is a potential source of environmental pollution and additional cost to farmers. Therefore, increasing emphasis in breeding wheat cultivars with improved NUE for reducing excessive input of fertilizers along with maintaining an acceptable yield is a global concern [1, 2]. Breeding of N-efficient cultivars is one approach to reduce N fertilizer inputs while maintaining acceptable yields [2]. Nitrogen use efficiency (NUE) is defined as the ratio of grain yield produced to mineral nitrogen available from the soil and fertilizer [3, 4]. N-use efficiency can be divided into two components: N-uptake efficiency (NUpE; crop N uptake per N available) and N-utilization efficiency (NUtE; grain dry matter yield per crop N).

NUE is, influenced by genotype [5]. The NUE genotypic variation of bread wheat [6, 7] and durum wheat [8] was attributed to high N uptake and/or high N utilization [9]. Thus, selecting NUE efficient genotypes would lead to the reduction of N applications and then environmental risk [8]. Besides, the integration of agro-physiology and molecular N pathway traits to screen wheat genotypes seem to be useful to optimize yields and NUE [10].

The potential for breeding for N use efficiency in crops is dependent on the genetic variability present in the species for the trait(s) that determine efficient N utilization, and hence genetic variability for NUE trait in wheat genotypes leads to success in identifying and selecting wheat lines and cultivars having morphological and physiological characteristics suitable for higher yields and nitrogen utilization efficiency [11, 12].

The main objective of the study is to assess the extent of genetic variability in wheat genotypes for nitrogen use efficiency (NUE), identification and selection of wheat genotypes with higher NUE based on various morpho-physiological traits.

Materials and Methods

The present experiment was conducted to assess the genetic variability for NUE in wheat based on different morpho-physiological traits in eight four-wheat genotypes. These lines were selected based on their wider adaptability to different agro-climatic regions as well as diverse growing conditions. It comprised of released varieties/cultivars, local germplasm of India and CIMMYT advanced breeding lines from different nursery (SATYN, CISA-HTEM, WYCYT and SAWSN). The details of the genotypes used for the study are presented in [Table-1].

The 84 genotypes were sown to test their nitrogen use efficiency at 2 different levels of nitrogen T0-without external nitrogen (0% RDF) and T1-100 kg of N/ha (RDF) in alpha lattice design with two replications during *rabi* 2014-15 at All India Coordinated Wheat Improvement Project, Main Agricultural Research Station, University of Agricultural Science, Dharwad. Geographically, the experimental site is located between 15°-31° N latitude and 76"07' E longitude and has an altitude of 750 m above mean sea level. It comes under the transition tract of Karnataka state. Soil sample were done before sowing and after harvest, the nutrient status is presented in [Table-2].

The morpho-physiological observations like SPAD for chlorophyll content and Normalized differential vegetative index (NDVI) at 3 different stages (booting stage, anthesis and grain filling stage), days to 50 per cent flowering, days to maturity, plant height(cm). Yield attributing traits like number of tillers per meter row, spike length, number of spikelet's per spike, thousand grain weight (g), grain yield (q/ha) and biomass (q/ha). NUE component traits like harvest index (%), grain protein content (%), grain N (%) and straw N content were analyzed by Micro-kjeldhal digestion method as per FAO guide to laboratory establishment for plant nutrient analysis [13] nitrogen use efficiency (NUE) components [3, 14].

1. NHI (Nitrogen harvest index) = Grain N/ (Grain N + straw N) × 100; (%).
2. Total nitrogen uptake (TNUp): This component was determined as the sum of Nitrogen in straw and grain at harvest ((kg N/ha).
3. Nitrogen uptake efficiency (NUpE): = Total N uptake/crop N supply (fertilizer N + soil mineral N at planting) × 100; (%).
4. Nitrogen utilization efficiency for grain yield (NUtE) = grain yield/total N uptake; (kg grain yield/kg N uptake).
5. Nitrogen use efficiency for grain yield (NUE): This component was calculated as the grain yield/crop N supply (fertilizer N + soil mineral N at planting)

Table-1 *List of 84 wheat genotypes for nitrogen use efficiency*

SL. No	Genotype Name	SL. No	Genotype Name	SL. No	Genotype Name	SL. No	Genotype Name
1	AKW 1071	26	K 68	51	UASDW 30037	CIMMYT advanced breeding lines	
2	ALTAR 84	27	K 9107	52	UASDW 30098	69	2 nd WYCYT 34
3	AMRUT	28	KENPHAD 39	53	UP 2338	70	2 nd WYCYT 41
4	Bijaga Yellow	29	MACS 1967	54	UPD 93	71	2 nd WYCYT 42
5	C 306	30	MACS 6145	55	VL 404	72	3 rd SATYN 9402
6	CHOTI LERMA	31	MOTIA	56	VL 829	73	3 rd SATYN 9403
7	DWR 1006	32	MPO 1215	57	WH 1021	74	31 st SAWSN 3088
8	GW 322	33	NARBADA 4	58	WH 1022	75	31 st SAWSN 3102
9	HB 208	34	NI 5749	59	WH 147	76	34 th ESWYT 115
10	HD 2967	35	NI 917	60	WH 542	77	46 th IBWSN 1005
11	HI 8381	36	NIDW 295	61	DBW 39	78	46 th IBWSN 1135
12	HI 8638	37	NIPHAD 4	62	HD 2189	79	5 th CISA HTEM 10211
13	HI 8704	38	NP 825	63	HD 2733	80	5 th CISA HTEM 10212
14	HPW 147	39	NP 846	64	KALYANA SONA	81	5 th CISA HTEM 10219
15	HPW 251	40	PBW 175	65	KRL-19	82	8 th EBYT 522
16	HS 240	41	PBW 550	66	PBW 343	83	EHT 29 SAWSN 3129
17	HS 277	42	PDW 215	67	RAJ 4294	84	EHT 46 IBWSN 1088
18	HS 365	43	PDW 233	68	UAS-304		
19	HUW 12	44	PDW 291				
20	HUW 206	45	RAJ 1972				
21	HYB 633	46	RAJ 4248				
22	IWP 72	47	RW 346				
23	JNK-4W-184	48	Sujata (HI 617)				
24	K 307	49	UAS 323				
25	K 53	50	UASDW 30025				

Table-2 *Soil nutrient analysis before sowing and after sowing 2014-2015*

Nutrient status of soil before sowing				
	OC	N	P	K
Sample	%	kg/ ha	kg/ha	kg/ha
T0R1	0.66	190.00	86.36	282.60
T0R2	0.67	186.00	73.22	270.20
T1R1	0.77	163.47	83.56	245.60
T1R2	0.63	183.90	80.77	214.60
Nutrient status of soil after harvest				
	OC	N	P	K
Sample	%	kg/ ha	kg/ha	kg/ha
T0R1BS7	0.68	178.00	93.25	228.80
T0R2BSB	0.66	176.00	84.12	235.80
T1R1BS3	0.75	194.12	90.83	211.00
T1R2BS4	0.71	204.34	98.81	220.20

The genetic variability traits like genotypic coefficient of variance (GCV) and phenotypic coefficient of variance (PCV) was calculated by the formula given by [15]. Heritability in broad sense was calculated by the formula given by [16]. From the heritability estimates, the genetic advance was calculated by the following formula given by [17].

Results and Discussion

Breeding wheat cultivars with high nitrogen uptake capacity and nitrogen use efficiency under low nitrogen input conditions is a key to reduce nitrogen application in wheat production systems [18]. The observation of considerable variation for grain yield and NUE at T_0 and T_1 conditions indicates that significant genetic variation exists in most Indian wheat cultivars. Thus, these germplasm can be used for developing wheat varieties with higher efficiencies of nitrogen uptake and use, and suitable for low input wheat production system. Genetic variability is a pre requisite for selection of any breeding method and genetic improvement.

The variability parameters range, mean, PCV, GCV, heritability in broad sense and genetic advance percent mean for T0 (0 % RDN) and T1 (100 kg/ha: RDN) have been presented in [Table-3 & 4]. There is significant variation among the 84 genotypes for morpho-physiological traits, yield and yield attributing traits and nitrogen use efficient traits in both T0 and T1. The mean performance of genotypes for moropho-physiological, yield and NUE, NUpt, (NUtE), NHI, component traits were significant among the genotypes in both T0 and T1, it indicates significant genetic variation exist in present material.

The morpho-physiological traits show wide variations, the chlorophyll content before anthesis (SPAD-1) ranges from 30.15 to 46.15 in T0 and in T1 average of 44.25 (range 35.20 to 51.15). The mean performance of the genotypes chlorophyll content at the anthesis stage (SPAD-2) ranges from 28.9 to 48.65 with a mean of 41.36 in T0 and T1 it varied from 39.9 to 58.85 with a mean of 49.97. NDVI for vegetative coverage at anthesis stage in To varied from 0.29 to 0.62 with a mean of 0.43, T1 ranges from 0.46 to 0.76 (0.68). It indicates significant variation in chlorophyll content and NDVI at the anthesis stage in T0 and T1, days to flowering varied from 54.5 to 94.5 (71.82 days) and 59 to 96 (76.77 days) in T0 and T1 respectively, difference in days to flowering and days to maturity were observed,

the genotypes are early flowering in T0 compared to a T1.
Yield and yield attributing traits *viz.*, number of spikelet's per spike ranges from 13 to 17 with a mean of 14.97 in To and 11.61 to 20.34 with a mean of 17.01 in T1, similarly for average spike length of 8.2 (5.34 to 10.17) and 9.44 (6.83 to 12 cm) in To and T1 respectively, the number of tillers per meter row was ranged from 53.4 to 104 with a mean of 74 in To and T1 varied from 73.5 to 116.5 (94.3), the average thousand grain weight of 33.65 (27 to 40.88 g) and 36.65 (28.8 to 48.0), it indicate wide range of variation in genotypes for yield attributing traits. These traits were significantly affected by level of nitrogen.

Table-3 *Genetic variability parameters for morpho-physiological trait of 84 genotypes without external Nitrogen (T0)*

SL. No	Traits	Mean	Range		GCV	PCV	h^2 (%)	GAM
			Lowest	Highest				
1	Chlorophyll content at booting SPAD.I	38.94	30.15	46.75	7.93	9.55	68.90	13.57
2	Chlorophyll content at anthesis stage (SPAD-2)	41.36	28.90	48.65	7.96	9.38	72.00	13.91
3	Chlorophyll content at grain filling stage (SPAD-3)	36.27	23.20	44.65	9.96	11.56	74.10	17.66
4	NDVI.I	0.44	0.34	0.54	8.06	13.46	35.80	9.94
5	NDVI.II	0.43	0.29	0.62	11.96	17.99	44.20	16.39
6	NDVI.III	0.36	0.25	0.46	9.49	14.09	45.40	13.16
7	Days to fifty percent flowering (DFF)	71.82	54.5	94.5	15.64	15.71	99.10	32.06
8	Days to maturity	102.68	85.50	129	10.83	10.88	99.00	22.21
9	Plant height (cm)	78.07	62.67	99.17	8.25	11.66	50.10	12.03
Yield and yield attributing trait								
10	Number of spikelet's per spike	14.97	13.00	17.00	2.64	7.91	11.00	1.82
11	Spike length (cm)	8.20	5.34	10.17	9.47	14.45	43.00	12.79
12	Tiller per meter row	74.00	53.50	104.00	12.68	14.01	82.00	23.65
13	Thousand grain weight (g)	33.65	27.00	40.88	8.78	13.27	43.80	11.97
14	Grain yield (q/ha)	20.13	11.17	30.5	18.67	21.85	73.00	32.85
15	Biomass (q/ha)	58.80	32.63	78.65	14.58	18.32	63.30	23.91
16	Harvest Index (%)	34.38	23.97	45.55	8.64	13.87	38.80	11.09
Nitrogen use efficiency and related traits								
17	Protein content (%)	12.35	6.77	14.57	2.19	11.57	36.00	0.86
18	Grain N %	1.90	1.66	2.24	2.20	8.96	60.00	1.11
19	Straw N %	0.47	0.32	0.79	15.02	22.25	45.60	20.88
20	Nitrogen harvest index % (NHI)	80.33	70.95	86.54	2.92	4.55	41.10	3.85
21	NUE	10.50	5.80	16.00	18.67	21.85	73.00	32.86
22	Nitrogen uptake efficiency (NUpE)	98.35	55.47	143.81	13.67	19.45	49.40	19.78
23	Nitrogen utilization efficiency (NUtE)	10.85	7.81	14.25	7.54	14.65	26.50	8.00

Table-4 *Genetic variability parameters for morpho-physiological trait of 84 genotypes with (100 kg/ha) Nitrogen (T1)*

SL. No	Traits	Mean	Range		GCV	PCV	h^2 (%)	GAM
			Lowest	Highest				
1	Chlorophyll content at booting SPAD.I	**44.25**	35.20	51.15	7.90	8.59	84.50	14.95
2	Chlorophyll content at anthesis stage (SPAD-2)	**49.97**	39.90	58.85	7.24	8.34	75.20	12.93
3	Chlorophyll content at grain filling stage (SPAD-3)	**44.55**	31.25	52.85	8.97	10.11	78.70	16.39
4	NDVI.I	**0.55**	0.35	0.71	13.57	14.59	86.50	26.01
5	NDVI.II	**0.68**	0.46	0.76	4.82	8.46	32.50	5.66
6	NDVI.III	**0.48**	0.29	0.63	9.60	12.14	62.50	15.63
7	Days to fifty percent flowering (DFF)	**76.77**	59.00	96.00	12.74	12.84	98.40	26.02
8	Days to maturity	**107.02**	87.50	127.00	9.71	9.76	98.00	19.89
9	Plant height (cm)	**78.88**	62.00	105.17	10.41	12.75	66.60	17.50
Yield and yield attributing traits								
10	Number of spikelet's per spike	**17.01**	11.67	20.34	10.41	11.94	76.00	18.72
11	Spike length (cm)	**9.44**	5.83	12.00	13.80	17.06	65.50	23.01
12	Tiller per meter row	**94.30**	73.5	116.5	9.76	12.93	56.90	15.17
13	Thousand grain weight (g)	**36.65**	28.08	48.00	10.02	12.87	60.70	16.08
14	Grain yield (q/ha)	**27.78**	15.13	45.67	24.26	25.64	89.50	47.29
15	Biomass (q/ha)	**81.55**	34.55	117.00	19.58	22.52	75.60	35.09
16	Harvest Index (%)	**34.38**	22.39	46.72	14.42	17.64	66.90	24.3
Nitrogen use efficiency and related traits								
17	Protein content (%)	**15.02**	11.43	18.10	5.96	9.98	57.00	7.33
18	Grain N %	**2.32**	1.68	2.78	4.43	10.94	16.40	3.70
19	Straw N %	**0.62**	0.41	1.11	17.75	19.75	80.7	32.86
20	Nitrogen harvest index % (NHI)	**78.79**	68.56	84.86	3.42	4.77	51.30	5.04
21	NUE	**9.80**	5.30	16.10	24.26	25.64	89.50	47.3
22	Nitrogen uptake efficiency (NUpE)	**112.54**	52.97	155.37	16.56	20.01	68.50	28.23
23	Nitrogen utilization efficiency (NUtE)	**8.75**	5.14	12.91	15.04	18.32	67.40	25.44

The grain yield in T0 ranged from 11.17 to 30.50 (q/ ha) with a mean of 20.13 (q/ ha) and T1 varied from 15.13 to 45.67 (q/ ha) with an average yield of 27.78 (q/ ha). The effect of genotype N level interaction was significant for all 84 genotypes. The results are similar to earlier workers [19], grain yield significantly influenced by N application, grain yield higher in T1 compare to low N (T0).
The biomass significantly affect by N levels, T0, it varied from 32.63 to 78.65 (q/ha) with a mean of 20.13 (q/ha), T1 ranges from 32.63 to 117 (q/ha) with an average of 81.55 (q/ha). The biomass increased with increase in N level. Similar, results were also reported by [19]. Harvest index (HI) varied from 23.9 to 45.55 (34.38 %) high in T0 compared to T1 34.3 % (22.39 to 46.72), [20] reported genotypes also differ in their capacity to produce dry matter at a given level of N supply.
The mean protein content in T0 is ranged from 6.77 to 14.57 % with a mean of 12.35%, average protein in T1 varied from 15.02 % (11.43 to 18.1%), grain protein

content in wheat increased with higher N rate. The highest protein value obtained with increased N rate compare to T0 [21], Grain N ranges from 1.66 to 2.24 (1.9 %) and 1.68 to 2.78 (2.32 %) in T0 and T1 respectively, straw N varied from 0.32 to 0.79 (0.47 %) in T0, in T1 ranges from 0.41 to 1.11 % (0.62 %), grain and higher straw N was observed in high N level.

The nitrogen harvest index (NHI) ratio nitrogen content in grain and in the whole plant is a measure of the efficiency of nitrogen translocation from vegetative organs to the grains. NHI reflects the grain protein content and thus the grain nutritional quality [1]. NHI was high in T0 (80.33%), compared to a T1 (78.93%) it indicated variation in nitrogen harvest index among genotypes, due to efficient uptake of N and re-assimilation of N to economic part T0 is having high NHI compare to T1. [22, 23] reported NHI for wheat ranges from 0.70 to 0.80.

Similarly NUpE nitrogen uptake efficiency, high in T1 about 112.54 (52.97 to 155.37) compares to T0 98.35 (55.47 to 143.81) due excess availability of N leads to high uptake in T1. The N utilization efficiency is high in low N (T0) 10.85 (7.81 to 14.25) compared to T1 8.75 (5.14 to 12.91), T0 treatment it indicates variation in genotypes for ability to the observed N content from soil and effectively utilize the N to economic parts. According [5, 24]. N uptake in biomass was the most important factor in NUE determination regardless of N level.

NUE is ranged from 5.8 to 16 with a mean of 10.5 in T0 high compare to T1 5.3 to 16.1 (9.8). A wide genetic variability for NUE in wheat was attributed to high N uptake and/or high N utilization [9]. Similarly NUE genotypic variation among the bread wheat has been reported [6, 7] and durum wheat [8]. Increasing NUE can be achieved by improving NUpE or NUtE or by increasing the efficiency of both the components.

The high PCV and moderate GCV were recorded for grain yield, straw N% and NUpE, The moderate GCV and PCV were recorded for NDVI at the grain filling stage, days to fifty percent flowering, days to maturity, tiller number per meter row and NUpE. Low GCV and PCV observed for SPAD at the booting stage, NDVI at anthesis stage, number of spikelets per spike and grain N in T0 treatment. In T1 low GCV and PCV were observed for SPAD at booting stage and anthesis stage, NDVI at the anthesis stage and grain filling stage, days to maturity and protein content. The moderate GCV and PCV for most of traits like NDVI at booting stage, to fifty percent flowering, plant height, Number of spikelets per spike, spike length, thousand grain weight, harvest index (%), straw N and NUtE were observed. Whereas, the high PCV and GCV were recorded for grain yield, biomass and NUE.

High heritability coupled with high genetic advance percentage mean for days to fifty percent flowering, days to maturity, number of tiller per meter row, grain yield and biomass and moderate heritability and GAM for NDVI-2 and NDVI-3, thousand grain weight, harvest index (%) and NUpE were observed in T0 N level. Whereas, low heritability and GAM for number of spikelets per spike and straw N and NUtE.

T1 nitrogen level shows high heritability coupled with high genetic advance as % of mean was recorded in NDVI at anthesis stage, days to fifty percent flowering, spike length, grain yield, biomass, harvest index (%), straw N, NUtE, NUpE and NUE. Whereas, high heritability coupled with moderate GAM was seen for SPAD at booting stage and anthesis stage, grain filling stage, NDVI at grain filling stage, days to maturity, plant height, number of spikelets per spike and thousand grain weight. The traits like the number of tillers per meter row, protein content and nitrogen harvest index, moderate irritability and low heritability with GAM was shown by grain N.

Estimates of heritability and genetic advance are critical for predicting genetic improvement for any quantitative trait [25]. Heritability estimates indicate the effectiveness of selection for phenotypic performance of a particular character. The high heritability estimates along with high genetic advance is more useful for the selection [17]. In the present study high heritability along with high genetic advance was obtained for days to fifty percent flowering, spike length, grain yield, biomass, harvest index, straw N, nitrogen uptake efficiency (NUpE), nitrogen utilization efficiency (NUtE) and nitrogen use efficiency (NUE). The selection pressure can be applied in the desired direction on the basis of phenotype to improve these characters. These traits are the most important quantitative traits to be taken into consideration for effective NUE genotypes selection in wheat.

The four key variables determining N-efficiency in a wheat crop are grain yield, grain %N, total N-uptake and NHI. In order to identify high NUE lines, the mean performance of top ten genotypes with respect to yield (q/ha) among the two nitrogen levels were initially considered.

Table-5 *Top 10 genotypes in T0 and T1 treatments*

T0 (No external N)			T1 (100 kg/ha)	
Genotypes	Rank		Genotypes	Rank
2 nd WYCYT 34	6		2 nd WYCYT 34	4
2 nd WYCYT 41	7		3 rd SATYN 9403	2
3 rd SATYN 9403	9		5 th CISA HTEM 10212	1
46 th IBWSN 1005	2		5 th CISA HTEM 10219	6
5 th CISA HTEM 10211	1		EHT 46 IBWSN 1088	3
5 th CISA HTEM 10212	4		GW 322	7
EHT 29 SAWSN 3129	10		HD 2967	8
EHT 46 IBWSN 1088	8		K 9107	10
PBW 343	3		PBW 343	9
WH 1022	5		WH 1022	5

The mean performances of top 10 high yielding entries at different treatments of nitrogen genotypes presented in [Table-5], while in T0 (no external dose of nitrogen) genotypes, 5th CISA HTEM 10211, 46th IBWSN 1005, PBW 343, 5 th CISA HTEM 10212, WH 1022, EHT 46 IBWSN 1088, 2nd WYCYT 41, 3rd SATYN 9403, 2nd WYCYT 34 and EHT 29 SAWSN 3129 were found to be top yielders [Table-5]. The top 10 high yielding entries at 100 Kg N/ha (T1) were 5th CISA HTEM 10212, EHT 46 IBWSN 1088, 3 rd SATYN 9403, 2nd WYCYT 34, WH 1022, 5th CISA HTEM 10219, GW 322, K 9107, HD 2967 and PBW 343.

In this experiment genotypes *viz.,* 2nd WYCYT 34, 3rd SATYN 9403, 5th CISA HTEM 10212, WH, 1022, were found superior in high yield and NUE efficiency in both T0 and T1 nitrogen levels and their performance was stable across the different nitrogen levels. These identified lines would be further used as potential donors in development of the high nitrogen use efficient wheat varieties. These varieties when incorporated into functional and sustainable farming systems will help close the gap between actual and economically realistic yields.

Conclusion

The information on the genetic parameters can help the breeder to develop cultivars suitable to particular growing conditions. The knowledge on heritability is helpful to decide the selection procedure to be followed to improve the trait. Hence, it is concluded that traits like grain yield, biomass, harvest index, straw N, nitrogen uptake efficiency (NUpE), nitrogen utilization efficiency (NUtE) and nitrogen use efficiency (NUE), can be considered as suitable selection criteria for the development of high yielding NU efficient bread wheat varieties that suited to low N level. The top superior genotypes *viz.,* 2nd WYCYT 34, 3 rd SATYN 9403, 5th CISA HTEM 10212, WH 1022, were shown high NUE with yield. These identified lines could be used as a potential donor for development of nitrogen use, efficient wheat varieties or directly released for cultivation, which will greatly facilitate the resource poor farmers to enhance the productivity.

Conflict of Interest: None declared

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