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Research Article

Evaluation of Growing Degree Days Accumulation and Agro-Climatic Indices in Different Genotype of Wheat in Far-Western Hills, Nepal

Shalik Dangi[1]* and Abhisek Shrestha[2]

[1]*Department of Pathology, Institute of Agriculture and Animal Science, Tribhuvan University, Nepal*

[2]*Technical Officer in Plant Breeding and Genetics, NARC, Nepal*

***Corresponding Author**: Shalik Dangi, Department of Pathology, Institute of Agriculture and Animal Science, Tribhuvan University, Nepal.

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Abstract

In Doti, The field experiment was conducted in winter season in simple randomized design in order to investigate about the agro-climatic indices at heading and biological yield for 9 genotypes along one variety as a check variety. The number of days to reach heading and maturity stage showed significant effect. The earliest heading was seen in WK 2437, WK1792 and BL4363 with accumulated average of GDD 808.7°C, 809.5°C and 838°C respectively in wheat genotypes. The late heading was seen in WK1204 followed by the WK2414, NL 1164 with a GDD requirement of 849.5°C and 843.2°C. WK2278 and WK1204 genotypes required HUE for grain yield (1.518 and 1.479 kg/ha/°C, respectively). The HUE at biological yield for NL 1164 (7.751 kg/ha/°C), WK 1792 (6.614 kg/ha/°C), Chyakhura (6.348 kg/ha/°C), BL 4363 (6.402 kg/ha/°C) and WK2437 (6,017 kg/ha/°C) but lowest was recorder in WK2278(3.54 kg/ha/°C. the grain yield was negatively correlated to GDD at growing stage (r = -0.350**) but positive correlation to heat use efficiency(r = 0.99**)and similar way biological yield was also negatively and positively (r =- 0.39*) and (r = 0.987**) related to indices. Thus from study, it can be recommend that early variety (precocious) and moderate genotype like WK2437, WK2438 for Doti district (Drought area).

Keywords: *Grain Yield; Growing Degree Day; Stage; Temperature*

Introduction

In Nepal, wheat stands third important crops after Rice and Maize. It is grown in winter season range from temperate irrigated to dry and high rainfall areas and from warm humid to dry cold environments which is widely adapted. This nature made the adaptation possible, have high plasticity. C3 (3 carbon pathway cycles) cycle nature thrive plants to cool environment. Timely Sowing of wheat is one of the most important governing factor for affecting the crop phonological development and efficient conversion of biomass in to economic yield. Sowing at normal time has longer growth duration as compared to late sowing, which consequently provides an opportunity to accumulate more biomass and henceforth manifested in higher grain and biological yield [1]. The crop when exposed to sub-optimal and supra-optimal at different stage lead to forced maturity and reduces the yield which is caused by late sowing. The suitable variety at good results to higher productivity. Due to thermo-sensitive crop, seeding time and good variety has get importance. Temperature plays important role in growth and development of plants. The phenology and yield under field condition with accumulated heat system was influenced by temperature [2]. The plant have definite temperature requirement as per their phonological stages. Each development stage of plant accumulation of degree-days which is relatively constant and independent of sowing date; crop variety may modify, it considerably. Under Nepal condition, the maturity of wheat hastened due to gradual rise in ambient temperature under delayed planting. Hence, it becomes crucial to have knowledge and concept of exact duration of phenological stages in a particular crop-growing environment and their impact on yield of crop. Therefore, an experiment was conducted in determining the phenology and heat unit requirement of promising wheat varieties under different crop growing environment of mid-hills zone of Doti, Nepal.

Materials and Methods

Vegetal material

Ten wheat genotypes namely WK2278, WK2414, WK2437, WK2438, WK1792, Chyakhura, WK1204, NL1190, NL1164 and BL4363 were evaluated for their degree days requirement to reach heading stage and its correlation with their performance.

Trial design

A field experiment was conducted during 2015/2016 cropping season at Regional Agriculture Research Station, Bhagetada, Doti, located in the mid-hills of Far-Western Region Nepal (Altitude of 780m). The soil of experimental site was a clay loam and having pH = 7.5. The trail was laid out in completely randomized design with 3 Replications. The organic manure were managed at 6 t/ha. The sources of organic manure are farm yard manure and were applied in the trial field. Nitrogen, phosphorus and potash were applied as 60:40:20 kg ha-1 in field. Only half dose of Nitrogen and full dose of phosphorus and potash were applied as basal dose. Remaining half dose of Nitrogen was applied in the two split dose after first irrigation and milking stage. Spacing:row to row = 15 cm and continuous sowing. The record was done of Meteorological data, maximum, minimum and average temperature (°C) during vegetative and reproductive stage (Table 1). Temperatures data shows that durum wheat crop had exposed to various thermal regimes during vegetative and reproductive phase of the crop.

Month	Max temp.	Min temp.	Average	Rainfall
October	31.1451613	15.9	23.52258	1.709677
November	27.7466667	10.29	19.01833	0
December	23.6290323	4.870968	14.25	0
January	22.8580645	4.074194	13.46613	0.006452
February	26.3827586	7.5	16.94138	1.134483
March	31.3064516	11.8	21.55323	1.354839
April	36.7833333	16.40333	26.59333	0

Table 1: *Meteorological data, maximum, minimum and average temperature (°C) and Rainfall for 2015/2016 cropping season in Doti.*

The Agro-meteorological indices growing degree days (GDD), helio-thermal unit use efficiency(HTUE), heat use efficiency (HUE), Radiation use efficiency (RUE), Heat thermal unit (HTU) was calculated on the basis of following formula (used from A Sourour., *et al*. [3]):

1. Growing degree days (GDD) = {(T max + T min)÷2}-Tb

(Tb = Base temperature = 100C for summer crops)

(Tb = Base temperature = 80C for winter crops)

2. Helio-thermal unit (HTU)= GDD x Duration of sunshine hours
3. Heat use efficiency (HUI) = Biomass yield (kg/ha) ÷ GDD
4. Helio-thermal unit use efficiency (HTUE) = Biomass yield (kg/ha) ÷ HTU
5. Radiation use efficiency (RUE) = Biomass yield (kg/ha) ÷ Radiation hours

Heading days data were recorded during the growth period, when approximately 50% of spikes had completely emerged from the boot. Grain yield was calculated for all genotypes.

Statistic analysis

Tukey test ($p < 0.05$) was used to note the significance difference between means. The correlation of agrometeorological indices with grain yield were analyzed by SPSS 21.0 version.

Result and Discussion

From the table 2, the earliest heading was seen in WK1792 and WK 1792 and whereas delay heading was seen in WK1204, NL1190, Chyakhura and WK2278 where moderate heading was seen in WK2414, WK2438 and BL4363. Similarly, the days of maturity for different variety were significant. The early ripen genotypes were WK1792, WK2437, WK2414, WK2438, NL1190, and NL1164 where Chyakhura (139.3 days), WK1204 (142 days) and WK2278 (139.3 days). WK1204 (881.3^{0}C), WK2278 (865.1^{0}C), Chyakhura (863.4^{0}C) had highest heat accumulation at heading stage similar at maturity stage. The least GDD at maturity for WK2437 (1092^{0}C), WK1792 (1070^{0}C) which was also similar to GDD at heading stage.

Genotypes	Days of Heading	Days of maturity	GDD at Heading	GDD maturity
WK2278	96 ab	139.3 a	865.1 ab	1208
WK2414	93 b	131.7 bc	849.5 b	1122
WK2437	86 c	129 bcd	808.7 c	1092
WK2438	91 bc	127.7 cd	836.4 bc	1076
WK1792	86c	127 d	809.5 c	1070
Chyakhura	96.67ab	139.3 a	863.4 ab	1210
WK1204	100 a	142 a	881.3 a	1235
NL1190	92.67 ab	130 bcd	847 b	1103
NL1164	92 b	12 bcd	843.2 b	1082
BL4363	91 bc	132 b	838 bc	1125
Average	92.33	132.6	844.2	1132.3

Table 2: *Biological/Gain yield and different agro-meteorological indices (Growing Degree Days (GDD), Helio-thermal unit (HTU) and Heat Use Efficiency (HUE)) calculated for used genotypes.*

**Means followed by different letters within for biological and grain yield have significant differences at the level of P < 0.05 for Tukey test.*

Genotypes	Grain yield (t/ha)	Biological yield (t/ha)	Heat use efficiency (Grain yield)	HUE (Biological Yield)	RUE	HTU	HYUI
WK2278	1.83 b	4.27	1.518	3.540	1.966	18860	0.2268
WK2414	2.942 a	6.08	2.621	5.423	3.014	17214	0.3536
WK2437	2.736 ab	6.50	2.523	6.017	3.294	16830	0.3902
WK2438	3.037 a	6.45	2.823	5.999	3.279	16594	0.3892
WK1792	2.913 a	7.08	2.722	6.614	3.621	16474	0.4297
Chyakhura	2.849 ab	7.61	2.371	6.348	3.524	18918	0.4070
WK1204	1.826 b	7.24	1.479	5.858	3.227	19432	0.3718
NL1190	2.606 ab	6.19	2.362	5.610	3.102	16943	0.3654
NL1164	3.553 a	8.39	3.298	7.751	4.255	16644	0.5035
BL4363	2.567 ab	7.24	2.273	6.402	3.549	17300	0.4159
Average	2.69		2.399	5.960	3.280	17521	0.385

Table 3: *Biological/Gain yield and different agro-meteorological indices (Growing Degree Days (GDD), Helio-thermal unit (HTU) and Heat Use Efficiency (HUE)) calculated for used genotypes.*

**Means followed by different letters within for biological and grain yield have significant differences at the level of P < 0.05 for Tukey test.*

WK 2414, WK2438, WK 1792 and NL 1164 genotypes recorded highest grain yield (2.942, 3.037, 2,913 and 3.553 t/ha, respectively) and highest heat use efficiency for grain (2.621, 2.823 and 3.298 kg/ha/°C). While, WK2278 and WK1204 genotypes had highest HUE for grain yield (1.518 and 1.479 kg/ha/°C, respectively) and lowest grain yield (1.83 and 1.826 t/ha). For HUE related to biological yield NL 1164 (7.751 kg/ha/°C), WK 1792 (6.614 kg/ha/°C), Chyakhura (6.348 kg/ha/°C), BL 4363 (6.402 kg/ha/°C) and WK2437 (6,017 kg/ha/°C) recorded the highest value and WK2278 (3.54 kg/ha/°C) recorded the lowest values. The genotype NL 1164 had highest radiation use efficiency (4.255 kg/ha/hr) and WK 2278 had lowest value (1.966 kg/ha/hr) whereas other genotype had RUE at between highest and lowest value and average RUE used by all genotype was 3,280 kg/ha/hr. The helio-thermal unit was found highest in WK 1204 (19432°C hrs) and lowest in WK 2438 (16595°C hrs) and average was 17521°C hrs. Similarly, Highest helio-thermal unit use efficiency was found highest in NL 1164 (0.503 kg/°C hrs) and lowest value in WK 2278 (0.2268 kg/°C hrs). The grain yield was negatively cor-

related to GDD at heading stage (r = -0.350**) and also positive correlation with heat use efficiency (r = 0.99**). Similar correlation was found in biological yield (r =- 0.39*) and (r = 0.987**) respectively to two indices. From the result, it indicates that late variety prior to less yield although uses high heat use efficiency and provides for plant more biomass accumulation. WK 1204 attain the heading phase with growing degree days about 881.3°C and showed the lowest grain yield (1826 kg/ha).

	Grain yield	Gdd heading	Gdd maturity	Biological yield	HUE (yield)	HUE (By)	HTU	HTUE	RUE
Grain Yield	1	-0.35	-0.499	0.749**	0.991**	0.808**	-0.502**	.810**	0.800**
Gdd heading		1	0.733**	-0.39	-0.409	-0.131	-0.125	-0.142	-0.125
Gdd maturity			1	-0.135**	-0.558**	-0.244*	0.99	-0.249	-0.227
Biological yield				1	0.706**	0.987**	-0.12	0.986**	0.990**
HUE (yield)					1	-0.244	-0.56**	0.778*	0.766**
HUE (By)						1	-0.23	1	0.99
HTU							1	-0.24	-0.21
HTUE								1	0.99**
RUE									1

Table 4: *Pearson correlation coefficients of biological and grain yield with agro-meteorological indices (growing degree days (GDD), photo thermal index (PTI) and heat use efficiency (HUE)) at heading.*

There is difference in heat accumulation GDD at heading and maturity stages of different genotype which is influenced by temperature [4] which was supported by Snyder., *et al*. [5] and Ruml., *et al* [6]. The average GDD requirement from planting to heading was 2705°C along the different response of genotype. Similarly, growth character is important for yield prediction [7,8] where heading stage, maturity days has strong interaction between genetics and the temperature occurs [9], the heat unit system or growing degree days (GDDs) shows a direct and linear relationship among plant growth and temperature which was explained [10]. The character of wheat was governed by genetics [11,12]. HUE tends to dry matter accumulation and depends on genetic factors and practical application [13] where Gill., *et al*. [14] found that the phenothermal index is affected by the growing environment and cultivars. Similarly, yield potential assessment in different growing conditions [15-37].

Conclusion

The agro-meteorological indices provide the relation and cause or effect of temperature on phonological behavior in plant whereas; it showed significant differences in heading duration stage among wheat genotypes. Similar, research should be conducted more and more for estimation duration for others phenological stages and further evaluation should be done under a wider range of genotypes and environment.

Conflict of Interest

Author has no conflict of interest.

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