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# Assessing Wheat Population for Yield and Desirable Agronomic Traits under Organic Agriculture

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## Abstract

Organic farming is emerging and growing across worldwide. In such farming system, composite crossed population (CCP) is one of approach that suitable under organic agriculture to buffer against fluctuation environments. The objective of the study was to assess the composite crossed population of wheat along with check for yield and desirable agronomic traits under organic. The analysis variance showed no significant difference among wheat genotypes for grain yield whereas a highly significant (p=0.002) difference for TKW. Composite population of HU-13-YQMS showed the highest TKW (43.23 g) and the lowest recorded for the check (37.43 g). A highly significant difference (P<0.001) was observed among wheat genotypes for the yellow rust incidence and severity across growth stages. The highest yellow rust severity (6.01) and incidence (92.27 %) was recorded on the check and followed by the population HU-08-UK comp and HU-08-YQMS at milk stage. Composite population of HU-13-YQMS showed comparable grain yield, very low disease incidence and severity. Our result highlighted that genetic diversity within varietal crossed population performed as yield as check, but increased the resilience of the population to limit the spread of disease expansion across growth stages than check (pure lines) under studied organic condition.

**Keywords:** Composite Wheat Populations; Organic Farming; Resilience; Yield

## Introduction

Organic farming is an integration of crop and livestock production system that strive for sustainability. It became emerging and growing in worldwide since the 1990s. Organic agricultural land is slowly increased in Europe as well the highest per capital consummation located in this continent while stable in Africa [1]. Africa also producing agricultural product but destine for export. For example, Ethiopia is producing organic coffee, sesame and other products.

Organic farming is reassessing agricultural practices which relied more on biological inputs rather than heavy usage of chemical fertilizers, pesticides and GMO varieties .The aim of organic farming is to produce healthy and environmentally friendly food by closing the nutrient cycle in ecosystem and low external inputs of chemical fertilizers, avoiding the use of pesticides and herbicides that adverse effect on environment as well Genetic modified organism [2]. On other hand, organic agriculture is advantage in terms of enhancing biodiversity (at the farm, crop, variety, soil biota) [3]. Additionally, organic farming integrates agro-diversity, resilience /or robust crop variety and agronomic practices in their ecological farming system. Notice that agricultural organic farmers need variety that adapted to organic condition and low input application. Since this can provide them insurance with resilience to biotic and abiotic stresses rather than application of synthetic chemicals [4]. Breeding for organic sector require the desired traits such as stable yield, good quality, seed health, better root system as well ability to interact with beneficial soil micro-organisms and suppress weeds [5;6;7]. Pure line of wheat which genetically uniform variety that is developed via pedigree methods are the dominant commercial breeding method to acquire high yielding and wide adaptability when recommended inputs applied and at right environment condition [8]. Though, these varieties cannot often perform well in marginal agriculture environments with low inputs applied and under organic condition. Besides, due to prohibited application of chemicals under organic condition, foliar diseases are more incurred yield limits [9]. For instance, the wheat yield loss due to yellow rust was 40-80% throughout the world [10]. Therefore, development of robust variety from broadened population that resistance to disease, optimize yield, resilience to fluctuation of environment and practices in their ecology farming system is as one strategy for organic farming.

Exploitation and broadening gene pool is one of the strategies of breeding for organic agriculture. This enables to select for important traits and development of a population variety that is adapted to ecological farming system [11]. For example; composite crossed population approach involves varietal crosses that can be increase genetic diversity within cultivars to help better adaptation towards unpredicted biotic and abiotic stresses. Therefore, the objective of this study was to assess the composite crossed populations of winter wheat for yield and desirable traits under organic condition.

## Materials and Methods

The trial was carried out at the organic farm of Wageningen University and Research Center, the Netherlands during 2013/2014. Seven composite cross populations and one pure line as check, totally eight wheat genotypes were used as treatment in a randomized complete block design (RCBD) with three replications. The plot size for each wheat genotype was 6 m x 7.5 m of area 45 $m^2$. The experimental seed was treated with Tillecur (based on organic mustard powder) whereas fertilizer and pesticides were not applied during experiment conducted.

## Collected Data

Yellow rust incidence assessment at 39, 61 and 83 growth stages

40 plants were tagged from each plot randomly. Yellow rust disease incidence for each plot was assessed at flag leaf sheath extending up (39), flowering (61) and milk growth stage (83). From each tagged plant, number of leaves and infected leaves was counted for disease incidence at these growth stages.

$$disease\ incidence\ (\%)\ =\ \left(\frac{Numberofinfectedplantunits}{totalnumberofplantunitsassesed} * 100\right)$$

$$\%\ incidence = \left(\frac{Numberofinfectedleave}{totalnumberleave}\right) =\ average\ infected\ leaves * 100$$

Yellow rust disease severity evaluation at 39, 61 and 83 growth stages.

Visual scales range from no symptoms score, 0 and or 1 as few isolated lesion, very severe symptoms score 9 and other categories in various disease symptoms at corresponding fallen number was scored. Severity of disease was scored visually per tagged plant and its mean taken [12] for what and barely disease severity evaluation. In addition, disease severity in percentage evaluated at these growth stages based on BBCH; Base, Bayer, Ciba-Geigy and Hoechst.

### Yield and other Agronomic Traits Data

**a) The distance between spikelet's:** 40 plants per plot were taken from tagged plants. Spike length was measured from these sampled plants. The number of spikelets per spike was calculated based on the following formula.

$$Distance\ between\ spikelets\ (cm) = \left(\frac{Lengthofspike}{numberofspikeletsperspike}\right)$$

**b) Plant height:** 40 plants per plot were taken from tagged samples. Plant height was measured in cm from these sampled plants and their average was considered as plant height.

**c) The distance from flag leaf to spike:** 40 plants per plot were taken from tagged samples. The distance from flag leaf to spike was measured in cm from these sampled plants and their average taken.

**d) Grain yield:** after physiological maturation, each genotype was harvested and grain yield per plot weighted and recorded. e) Thousand kernel weight (TKW): TKW weighted for each plot.

## Statistical Analysis

Statistical analysis conducted by using Genstat 16$^{th}$ edition software. Analysis of variance through REML that based on original data was performed to test genotypes as treatment effect and replication (block) as random structure. We used criterion for declaring significant P < 0.05 and mean separation comparison significant for treatments separated by Fisher protected LSD-test at 5%.

The correlation within morphological traits, between agronomic traits and disease was analyzed by using SPSS software correlation coefficient.

## Results

ANOVA showed highly significant differences (*P* <0.001) among wheat genotypes for yellow rust incidence (%) at flag leave, flowering and milk growth stages (Table 1). Furthermore, significant difference observed among composite crossed population for yellow rust incidence.at theses growth stages. The yellow rust incidence increases across the growth stages, for example, the highest yellow rust incidence (92.27%) was observed on the pure line (check), followed by composite cross populations B and A

(43.56 %) and (30.17 %) at milk stage

**Table 1:** Mean for the yellow rust incidence (%) at different growth stages for wheat population trial

| Genotype | Mean for yellow rust incidence of tagged samples | | |
|---|---|---|---|
| | YR_IncFL | YR_IncFW | YR_Inc MS |
| C (check/pure line) | 54.41 | 81.85 | 92.27 |
| B (HU-08-UK composite) | 33.73 | 41.68 | 43.56 |
| A (HU-08-YQMS) | 10.83 | 27.33 | 30.17 |
| G (HU-09-YQMS) | 11.08 | 17.53 | 18.33 |
| D (HU-10-YQMS) | 9.28 | 17.10 | 18.04 |
| E (HU-11-YQMS) | 7.91 | 17.13 | 23.04 |
| H (HU-12-YQMS) | 7.08 | 17.42 | 27.5 |
| I (HU-13-YQMS) | 9.72 | 12.43 | 24.17 |
| CV (%) | 14.60 | 20.70 | 22.50 |
| LSD at 0.05 | 4.86 | 20.20 | 16.34 |

Notice: YR_ IncFL= Yellow Rust Incidence at flag leave appeared stage, YR_IncFW= Yellow Rust Incidence at flowering stage, YR_Inc MS= Yellow Rust Incidence at milk stage.

Significant differences ($P$ <0.001) were observed among winter wheat genotypes for yellow rust severity (0-100% scaling methods) on the first flag leaf and the penultimate leaf at flowering and milk stages (Table 2). Also, significant differences were found among composite crossed population for yellow rust severity at these stages. The highest yellow rust severity (60.64%) was observed at the penultimate leaf at milk stage for the C (pure line), followed by populations A and B (15.44 and 15.50%), respectively.

**Table 2:** Comparison of mean for the yellow rust severity based on 0-9 scale and 0-100 % scoring methods at different growth stages

| Genotype | Mean for Yellow rust severity based on (0-100 % scale) | | | |
|---|---|---|---|---|
| | YSV1sfLF | YSV2ndfLF | YSV1sfLM | YSV2nfLM |
| C | 16.63 | 30.49 | 35.76 | 60.64 |
| B | 11.93 | 17.91 | 11.63 | 15.44 |
| A | 3.59 | 5.45 | 10.44 | 15.50 |
| G | 1.15 | 2.03 | 1.88 | 3.25 |
| D | 1.70 | 3.37 | 3.12 | 3.50 |
| E | 2.43 | 3.67 | 3.25 | 4.88 |
| H | 2.12 | 3.63 | 2.62 | 4.13 |
| I | 2.36 | 2.42 | 3.75 | 7.13 |
| CV (%) | 24.50 | 19.00 | 19.80 | 18.40 |
| LSD, 0.05 | 5.27 | 6.21 | 8.52 | 9.62 |

YSV1sfLF (0-100 % scaling) =Yellow Rust severity on the 1st flag leaf at flowering growth stage, YSV2ndfLF (0-100 % scaling) = Yellow Rust severity on penultimate leaf at flowering growth stage, YSV1sfLM (0-100 % scaling) = Yellow Rust severity on 1st flag leaf at milk stage, YSV2dfLM (0-100 % scaling method) = Yellow Rust severity on penultimate leaf at milk stage.

## Grain Yield and TKW

The Analysis of variance showed no significant difference ($P$=0.45) among wheat genotypes for grain yield. Other hand, highly significant differences ($P$=0.002) were found among all wheat genotypes for thousand kernel weight (TKW). The highest TKW was recorded for the population I (43.23 g) whereas the C showed the lowest TKW (37.43 g) (Table 3).

Significant differences observed among wheat genotypes for some agronomic traits; plant height ($P<0.03$), total number of spikelets ($P<0.014$) and the distance from flag leaf to spike ($P<0.007$) (Table 3). The longest genotype was the population E with an average length of 91.42 cm, while, population H had the shortest recorded average length of 76.28 cm.

**Table 3:** Comparison of mean grain yield (t/ha) and other agronomic traits for wheat genotypes under organic experimental farm

| Genotype | Grain yield (t/ha) | TKW (g) | FT/ $m^2$ | PLHT (cm) | SL(cm) | FL(cm) | FS | UFS | TS | DS |
|---|---|---|---|---|---|---|---|---|---|---|
| C | 2.86 | 37.43 | 421.4 | 80.75 | 8.86 | 14.99 | 16.63 | 4.27 | 20.90 | 0.41 |
| B | 2.65 | 41.35 | 326.33 | 83.07 | 7.48 | 15.90 | 13.79 | 3.92 | 17.71 | 0.42 |
| A | 3.18 | 41.43 | 444.33 | 82.89 | 8.16 | 15.53 | 15.70 | 3.56 | 19.27 | 0.43 |
| G | 3.26 | 40.96 | 453.33 | 79.11 | 7.93 | 17.19 | 14.87 | 3.66 | 18.53 | 0.43 |
| D | 3.17 | 42.58 | 500.90 | 82.94 | 7.99 | 16.55 | 14.74 | 3.28 | 18.02 | 0.44 |
| E | 3.39 | 41.88 | 440.40 | 91.42 | 8.65 | 20.47 | 15.94 | 3.83 | 19.32 | 0.45 |
| H | 3.15 | 39.80 | 450.33 | 76.28 | 7.66 | 14.08 | 14.71 | 3.91 | 18.62 | 0.41 |
| I | 3.39 | 43.23 | 465.00 | 82.54 | 8.00 | 17.11 | 14.44 | 3.57 | 18.41 | 0.44 |
| CV (%) | 13.90 | 2.90 | 13.85 | 4.60 | 5.70 | 8.20 | 5.60 | 13.85 | 4.10 | 3.52 |
| LSD, 0.05 | NS | 2.12 | NS | 7.03 | NS | 2.48 | 1.56 | NS | 1.42 | NS |

TKW (g) = Thousand kernel weight, FT per $m^2$= number of fertile tillers $m^{-2}$, PLHT= plant height (cm), SL= spike length in cm, FL= the distance between Flag leaf and spike in cm, FS= number of fertile spikelets, UFS = number of unfertile spikelets, TS =total number of spikelets / spikes, DS= the distance between spikelets

## Correlation Traits

Grain yield exhibited a significant positive association with TKW (r= 0.76), plant height (r= 0.64) and non-significant negative correlation with yellow rust incidence and severity. Similarly, plant height revealed a significant positive association with spike length (r= 0.66), flag leave to spike (r= 0.69), fertile spikelet (r= 0.52), distance between spikelet (r= 0.64) and non-significant with disease pressure. Also, spike length showed significant positive correlation with fertile spikelet's (r= 0.89) and the distance between spikelet (r= 0.62) (Table 4). However, majority of agronomic triats showed non-significant negative assocation with yellow rust incideance and seveirty. This might be due to the braoden genetic base of population increase resilance to yellow rust disease pressure under organic farming.

**Table 4:** Pearson correlation among agronomic triats and disease parameters in wheat genotypes tested under organic conditions

| | GY | TKW | plht | SL | FL | FS | UnfS | dS | YRIN | YRSV |
|---|---|---|---|---|---|---|---|---|---|---|
| GY | 1 | | | | | | | | | |
| TKW | 0.76$^{**}$ | 1 | | | | | | | | |
| plht | 0.64$^{**}$ | 0.54$^{*}$ | 1 | | | | | | | |
| SL | 0.21$^{ns}$ | 0.02$^{ns}$ | 0.66$^{**}$ | 1 | | | | | | |
| FL | 0.45$^{ns}$ | 0.42$^{ns}$ | 0.69$^{**}$ | 0.25$^{ns}$ | 1 | | | | | |
| FS | 0.24$^{ns}$ | -0.09$^{ns}$ | 0.52$^{*}$ | 0.89$^{**}$ | 0.09$^{ns}$ | 1 | | | | |
| UnfS | -0.69$^{ns}$ | -0.67$^{ns}$ | -0.54$^{ns}$ | -0.32$^{ns}$ | -0.40$^{ns}$ | -0.25$^{ns}$ | 1 | | | |
| dS | 0.44$^{ns}$ | 0.57$^{*}$ | 0.64$^{**}$ | 0.62$^{*}$ | 0.48$^{ns}$ | 0.19$^{ns}$ | -0.78$^{ns}$ | 1 | | |
| INFW | -0.21$^{ns}$ | -0.56$^{ns}$ | -0.01$^{ns}$ | 0.45$^{ns}$ | -0.31$^{ns}$ | 0.51$^{ns}$ | 0.19$^{ns}$ | -0.18$^{ns}$ | 1 | |
| YRSV | -0.26$^{ns}$ | -0.59$^{ns}$ | 0.02$^{ns}$ | 0.47$^{ns}$ | -0.24$^{ns}$ | 0.50$^{ns}$ | 0.32$^{ns}$ | -0.22$^{ns}$ | 0.95$^{**}$ | 1 |

GY= grain yield, TKW = Thousand kernel weight, Plht= plant height (cm), SL= spike length in cm, FL= the distance between Flag leaf to spike in cm, FS= number of fertile spikelets, Unfs = number of unfertile spikelets, ds= the distance between spikelets, YRIN= yellow rust incidence, YRSV= Yellow rust severity, ns= non-significant

## Discussion

### Yellow Rust Disease

In the current study, the yellow rust incidence and high severity exhibited on pure line (check) than crossed population of wheat under organic condition. This might be due to pure line is genetically uniform, narrow genetic based combination during line development via pedigree selection when compared to composite crossed population. Additionally, weak resistance of pure lines can explain due to low tillering capacity.

Even though the incidence and severity of yellow rust was more observed on the Composite population of A and B, it seems not economically important due to low severity. One of explanation is that the diversity within a population increased the resilience of the composite population to restrict the spread of disease expansion across growth stages than the pure line under organic farming. This observation tends to agree with [13; 14; 15] who argue that variety and multiline mixtures can provide functional diversity that limits pathogen expansion. It is likely that due to the diversity inter-varietal parents used to develop the population different combinations of resistance genes have been integrosed into the composite population and cause different barriers to restrict the spread and expansion of the pathogen.

### Yield and its Related Trait

Grain yield is a very complex trait and governed by several genes, physiological and biochemical plant processes [16]. The genetic potential of wheat composite crossed population did not show yield difference under organic farming. The mean of yield was low among wheat genotypes, this might be due to slow-release nutrient under organic condition. However, difference in magnitude. For instance, composite crossed population of HU-13-YQMS with the highest TKW showed a comparable performance in grain yield, yellow rust resistance and likely resilience population under organic condition. [17] reported that the differences among wheat genotypes for grain yield and genotype × system interaction under different growing conditions.

Morphological trait of plant height was the longest for the population E, medium in height recorded for population A and B, while the shortest observed for the population H. In present study the old and the newly population showed similar in plant height. This observation is in contrary with [18] who argues that the plant height of barley increased over the years of reproduction.

Our study revealed that spike length was positively correlated with the distance between spikelets and exerted positive effect through other traits. [19] reported that spike length had positive association with number of spikelets per spike. Increase in spike length is directly associated with increase in spikelet per spike as well as grain number per spike and contribute for the grain yield per plant. Therefore, plant height, spike length, grain per spike and thousand kernel weights should be considered for selection under organic conditions because these traits are directly contributing to grain yield.

## Conclusion

Our results suggest that the diversity within the CCPs can improve the resilience of the population under organic farming condition to suppress the spread of pathogens compared to the pure line. The composite crossed populations (CCPs) showed similar grain yield potential as pure line. Threfore, exploitation on source of genetic diversity of wheat will be required for further study and beneficial traits may be combined to develop a resilience cultivar to optimaize yield, resitance to disease and nutrient use efficiency under low input and organic conditions in their ecological farming system.

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