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Effect of Drought Stress on Morphology, Yield, and Chlorophyll Concentration of Hungarian Potato Genotypes

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Abstract: Different morphological traits have been studied to determine the drought tolerance of potato genotypes. In this study, a greenhouse experiment was conducted to investigate the effect of drought stress on morphology and yield with a focus on chlorophyll concentration (Chl) of two Hungarian potato genotypes (Hopehely and Demon) varying in drought tolerance. Two potato genotypes (Hopehely and Demon) were grown under two moisture levels i.e. 80% water holding capacity (control) and 50% water holding capacity (stressed). Results revealed that the drought-tolerant genotype (Hopehely) showed significantly higher chlorophyll concentration at each growth stage and produced higher yield under control as well as drought conditions. Drought stress significantly reduced chlorophyll concentration in both genotypes. Tuber yield positively correlated with chlorophyll concentration and specific leaf weight. Chlorophyll concentration varied significantly within the canopy of plants in all treatments. The highest chlorophyll concentration was recorded for the 3rd compound leaf, top leaflet, and top measuring point on the leaflet. Morphological growth of Demon was more sensitive to drought stress compared to Hopehely. This study showed that drought-tolerant genotypes produce higher amount of chlorophyll and maintain their chlorophyll concentration for a longer period even under drought stress.

Keywords: *Solanum tuberosum*; compound leaves; chlorophyll concentration; SPAD-502; water shortage stress,

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1. Introduction

Water is one of the most critical factors limiting crop productivity (Askari-Khorasgani et al. 2021; Dar et al. 2021). Drought affects plant growth in multiple ways depending upon the duration, intensity, and frequency of drought. Its effect is highly linked with the plant developmental stage (Pinheiro and Chaves, 2011).

The origin of cultivated potato (*Solanum tuberosum*), is traced back to Latin America. Now it is successfully grown under diverse agroclimatic conditions throughout the world (Bethke et al. 2019; de Haan and Rodriguez, 2016; Saeed et al., 2020). Potato is the 4th most important crop in the world. Due to its rapid increase in consumption, its contribution to regional and global food security is briskly increasing (Jennings et al. 2020). Consequently, sustainable, potato production can be critical to food security and poverty eradication in different regions, and in achieving Sustainable Development Goals (Sing et al., 2020; Wijesinha-Bettoni and Mouillé, 2019).

Potato production is predicted to decrease under changing climate conditions, including drought (Scott et al. 2019; Djaman et al., 2021). Potato developmental stages can be divided into five stages including plant establishment, stolon initiation, tuber initiation, tuber bulking, and maturity stage (Obidiegwu et al. 2015).

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Drought can affect potato yield by affecting vegetative growth such as plant height, number, and size of leaves produced by the plant (Deblonde and Ledent, 2001), or by affecting the photosynthesis in leaves by chlorophyll reduction or leaf area index reduction, or leaf area duration reduction. Besides vegetative growth, drought has been reported to affect the reproductive stage of potatoes by shortening the growth cycle (Kumar et al. 2007), or by reducing the size (Schafleitner et al. 2009) and/or numbers of tubers (Eiasu et al. 2007) produced by plants. Moreover, drought can also affect the quality of tubers produced (Ekanayake and Midmore, 1989; Jefferies, 1995).

Potato is a water-efficient crop (Sun et al. 2015) yet considered sensitive to drought stress (Schafleitner et al. 2009), which can be attributed to its shallow root system (Quandahor et al., 2021). Several canopy characteristics such as type of canopy (Aliche et al. 2018), number of leaves (Luitel et al. 2015), and leaf area index (Zarzyńska et al. 2017; Wadas, 2021) have been studied to determine drought tolerance of potato cultivars. Green leaves are the main organ of productivity in terrestrial plants. The presence of chlorophyll in leaves makes them the site of photosynthesis. Chlorophyll content in leaves is used to predict the photosynthetic capacity of the plant, physiological condition, and health of plants (Wright et al. 2004; Zhao et al. 2016). Chlorophyll pigments harness light energy and convert it into chemical energy. The concentration of photosynthetic pigment in the leaves and their concentration in leaves is affected by the nitrogen status of plants, water stress, and other plant stresses (Dai et al. 2009). Chlorophyll concentration may vary among specific parts of the foliage because of the plant growth stage, leaf thickness, leaf position, and the measuring points on the leaf (Ata-Ul-Karim et al. 2016). However, very little research has been reported to understand the effect of chlorophyll concentration variation on potato yield under drought stress.

This study was conducted to observe the morphological variations among Hungarian genotypes under drought stress conditions. This study also aimed to determine the chlorophyll concentration variance in potato plants under drought stress and to determine if there is any relation between chlorophyll concentration and drought tolerance of potatoes.

2. Materials and Methods

2.1. Plant materials and growth conditions

The experiment was conducted in the greenhouse of the Georgikon Campus, Hungarian University of Agriculture and Life Sciences (MATE), Keszthely, Hungary. Two genotypes – Demon and Hopehely – were exposed to two different water levels i.e. 80% water holding capacity (WHC) and 50% WHC. Randomized complete block design in the factorial arrangement was used with 16 replications.

Seed tubers of Demon and Hopehely were obtained from Potato Research Centre, Keszthely, Hungary. Soil and peat mixture (1:1 by weight) was used as growing media in 50 kg soil-bearing pots. Peat of Baltic origin was brought from Latvia and soil was collected from “A” horizon of a Eutric cambisol soil having a sandy clay loam texture from the research farm area of Georgikon Campus MATE. After sieving the soil and peat through a 10 mm sieve; a homogenized mixture was obtained by mixing them in a cement mixer.

Three tubers were sown in each pot. The moisture level was maintained at 80% WHC until the completion of germination (18 DAS) to ensure 100% germination. The gravimetric method was used to determine the water holding capacity of growing media. Pot weight at 80% WHC and 50% WHC was calculated and maintained from germination completion to harvesting. Drought was induced at germination completion (18 DAS). Random pots were weighed weekly to maintain desired water levels in the pots. Thinning was performed at germination completion to maintain 2 plants per pot.

2.2. Observations

2.2.1. Physiological observations

For physiological observations, 4 replications of each genotype at both water levels were harvested at four growth stages: 1. Tuber initiation stage (36 DAS); 2. Flowering stage (54 DAS); 3. Tuber bulking stage (72 DAS); 4. Senescence (90 DAS). At each harvesting data regarding plant height (cm), the number of leaflets per plant, average leaflet weight (g), leaf area index, specific leaf weight (g cm^{-2}), leaf area duration (days), nitrogen percentage in foliage (N%) and tuber yield (g $plant^{-1}$) was recorded.

Average leaflet weight (ALW) and specific leaflet weight (SLW) were measured by the following formula:

$$ALW = \frac{Total\ leaf\ weight}{Total\ number\ of\ leaflet}$$

$$SLW = \frac{Leaf\ weight}{Leaf\ area}$$

Leaf area index (LAI) and leaf area duration (LAD) were measured at each harvesting by using the following formula:

$$LAI = \frac{Total\ leaf\ area\ of\ plant}{Ground\ area\ occupied\ by\ plant}$$

$$LAD = \frac{LAI_1 + LAI_2}{2} \times (t_2 - t_1)$$

Where t_1 and t_2 are the time of first and second sampling and LAI_1 and LAI_2 are leaf area index at t_1 and t_2 respectively.

Nitrogen percentage in the foliage was determined by using an elemental analyzer. Leaf and stems were sun-dried followed by oven drying. The dried foliage was mechanically grounded to dust size particles and 100 mg samples were weighed in tin containers (8 × 55 mm) that were then shaped in the form of little round balls. The samples were then delivered to an elemental analyzer using 96 wells plates to determine nitrogen percentage in foliage.

2.2.2. Chlorophyll determination

Chlorophyll content per unit area was determined using Soil Plant Analysis Development (SPAD) 502. The readings were recorded in SPAD units. SPAD values on the top leaflet, 1st side leaflets, and 2nd side leaflets of the 3rd, 4th, and 5th compound leaf from the apex, and at 3 points (top, middle and basal) within a leaflet were taken weekly starting after tuber initiation stage (44 DAS). Three readings were taken for each point and then averaged; hence, 81 readings were taken from each plant (Fig. 1).

2.3. Statistical analysis

SPSS/PASW Statistics for Windows, version 18 (SPSS Inc., Chicago, IL, USA) was used for statistical analysis. Recorded data were subjected to factorial analysis at a 5% significance level followed by Fisher's Least Significant Difference (LSD) post hoc test to recognize specific differences among treatments. Kendall's rank correlation was performed to govern the association between variables. A $p < 5\%$ was considered significant.

3. Results

At the tuber initiation stage, genotypes showed a significant effect on all foliage characteristics while drought stress didn't show any significant effect on foliage development of either genotype except plant height of demon. Demon in comparison to Hopehely produced significantly taller plants, a greater number of leaflets, and higher leaf area index (LAI) under control as well as drought conditions; while Hopehely produced higher average leaf weight (ALW), specific leaf weight (SLW), and foliage nitrogen percentage (N%) under control as well as drought condition (Table 1).

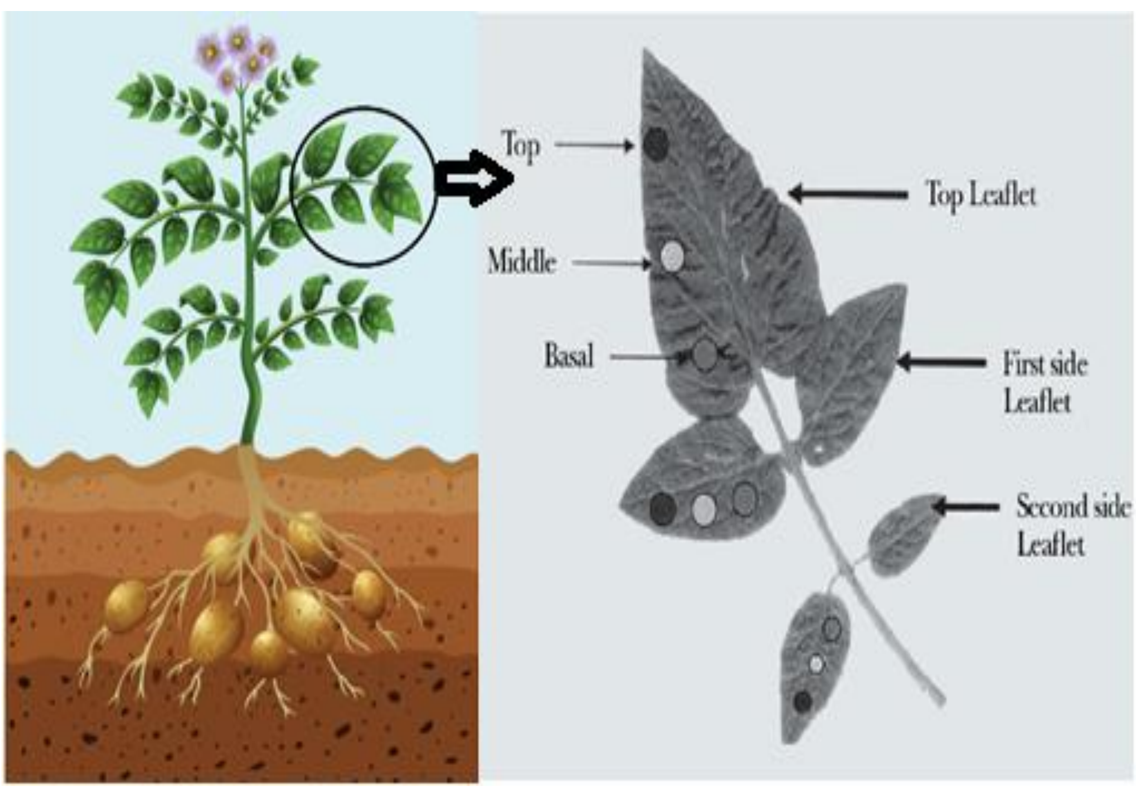

Fig. 1. Compound leaf, leaflet on the compound leaf, and measuring point on the leaflet of potato used for chlorophyll measurement (Adopted from Li et al., 2012)

Table 1. Effect of genotypes and drought stress on growth and yield of potatoes at various growth stages

Source of variation	Plant height (cm)	NOL	ALW	LAI	SLW	LAD	N%	TY
Tuber initiation stage (36 DAS)								
Genotypes (G)	0.002*	0.000*	0.00*	0.024*	0.02*	-	0.047*	0.18
Water levels (W)	0.038*	0.544	0.38	0.797	0.52	-	0.468	0.13
G × W	0.022*	0.597	0.95	0.404	0.51	-	0.118	0.09
Flowering stage (54 DAS)								
Genotypes (G)	0.004*	0.000*	0.00*	0.080	0.00*	0.005*	0.001*	0.58
Water levels (W)	0.020*	0.400	0.09	0.584	0.27	0.487	0.816	0.04*
G × W	0.000*	0.663	0.08	0.045*	0.12	0.019*	0.227	0.00*
Tuber bulking stage (72 DAS)								
Genotypes (G)	0.027*	0.000*	0.00*	0.964	0.07	0.347	0.000*	0.00*
Water levels (W)	0.004*	0.037*	0.61	0.325	0.56	0.332	0.816	0.02*
G × W	0.000*	0.039*	0.87	0.011*	0.019*	0.007*	0.088	0.02*
Senescence (90 DAS)								
Genotypes (G)	0.062	0.000*	0.00*	0.780	0.220	0.932	0.056	0.00*
Water levels (W)	0.001*	0.021*	0.05*	0.002*	0.644	0.028*	0.004*	0.66
G × W	0.011*	0.094	0.75	0.076	0.081	0.007*	0.157	0.15

***** $p \leq 0.05$. NOL- number of leaflets per plant; ALW- average leaf weight (g); LAI- leaf area index; SLW- specific leaf weight (g cm^{-2}); LAD- leaf area duration (days); N%- nitrogen percentage in foliage; TY- tuber yield (g)

Similar results were observed at the flowering stage where genotypes varied significantly in their foliage development except LAI for which no significant difference was observed and drought stress significantly reduced the plant height of Demon. At the tuber bulking stage, significant differences were observed between genotypes for plant height, number of leaflets, ALW, N%, and tuber yield. Demon produced significantly taller plants and a greater number of leaflets while Hopehely produced significantly higher ALW, N%, and tuber yield. Besides plant height, drought stress significantly reduced the number of leaflets in Demon at the tuber bulking stage (Table 1).

Table 2. Foliage characteristics of potato genotypes at different growth stages under different water levels

Genotype	Water level	Plant height (cm)	NOL	ALW	Leaf area index	SLW	Leaf Area Duration (days)	Foliage Nitrogen (%)	Tuber Yield (g)
Tuber initiation stage (36 DAS)									
Demon	WHC 80%	88.00a	72.62a	2.31b	7.58a	0.036b	-	4.92ab	1.66b
	WHC 50%	68.75b	67.25a	2.60b	6.86ab	0.040ab	-	4.07b	6.92a
Hopehely	WHC 80%	61.87b	38.00b	4.17a	5.32b	0.047a	-	5.10ab	2.25ab
	WHC 50%	63.13b	37.62b	4.50a	5.70ab	0.047a	-	5.42a	1.99b
Flowering stage (54 DAS)									
Demon	WHC 80%	117.50a	90.50a	2.14c	10.90a	0.029b	166.28a	3.03bc	184.88c
	WHC 50%	80.50b	85.12a	2.12c	8.16ab	0.035ab	135.17b	2.86c	300.75a
Hopehely	WHC 80%	76.25b	48.75b	3.46b	6.83b	0.040a	109.36b	3.52ab	269.79ab
	WHC 50%	89.25b	47.00b	4.43a	8.49ab	0.039a	127.81b	3.76a	236.45bc
Tuber bulking stage (72 DAS)									
Demon	WHC 80%	127.25a	74.87a	2.52b	13.47a	0.024b	219.38a	2.55b	379.96c
	WHC 50%	72.00b	58.50b	2.33b	7.540b	0.031ab	141.28b	2.35b	376.90c
Hopehely	WHC 80%	79.00b	49.25b	4.46a	8.938b	0.039a	141.88b	2.90a	543.80a
	WHC 50%	88.75b	49.12b	4.36a	11.95ab	0.028b	183.97ab	3.052a	443.53b
Senescence (90 DAS)									
Demon	WHC 80%	118.50a	80.00a	1.29b	7.89a	0.021b	192.32a	1.70a	503.06b
	WHC 50%	71.75b	60.62b	0.86b	3.29c	0.025ab	97.42c	1.11b	492.59b
Hopehely	WHC 80%	87.00b	41.50c	2.57a	6.59ab	0.026a	139.74bc	1.77a	664.84a
	WHC 50%	78.00b	37.75c	2.00a	5.02bc	0.024ab	152.73ab	1.54a	598.25ab

Means followed by different letters in the same column are significantly different (5% probability level); NOL- number of leaflets per plant; ALW- average leaf weight (g); SLW- specific leaf weight (g cm^{-2}); WHC, water holding capacity.

Table 3. Chlorophyll concentration variation in the canopy of potato genotypes in response to drought stress

Source of variation	44 DAS	51 DAS	58 DAS	65 DAS	72 DAS	79 DAS
Genotype	0.1713	0.1806	0.0000*	0.0000*	0.0000*	0.0000*
Water levels	0.0000*	0.0000*	0.0004*	0.0016*	0.0000*	0.0000*
Compound leaf	0.9290	0.2474	0.0228*	0.0245*	0.0006*	0.0000*
Leaflet	0.0000*	0.2139	0.1121	0.0001*	0.2151	0.0000*
Measuring point	0.0000*	0.0000*	0.0000*	0.0003*	0.0000*	0.0000*

*p≤0.05, DAS – Days after sowing

Table 4. Genotypic variation of potato leaf chlorophyll concentration, in response to drought stress

Source of variation	44 DAS	51 DAS	58 DAS	65 DAS	72 DAS	79 DAS
Demon (G1)	43.51a	43.28a	39.62b	35.94b	31.02b	26.75b
Hopehely (G2)	44.01a	43.80a	41.99a	39.15a	33.20a	28.54a
80% WHC (W1)	42.83b	42.28b	41.36a	38.07a	32.96a	29.55a
50% WHC (W2)	44.68a	44.80a	40.24b	37.02b	31.24b	25.74b
G1×W1	41.18d	40.17d	39.39c	36.05c	31.82b	28.48b
G1×W2	45.85a	46.40a	39.85bc	35.82c	30.22c	25.01d
G2×W1	44.49b	44.39b	43.34a	40.08a	34.10a	30.61a
G2×W2	43.52c	43.21c	40.64b	38.23b	32.30b	26.46c

Means followed by different letters in the same column are significantly different at the 5% probability level. WHC- water holding capacity, DAS, days after sowing.

At senescence, significant variation between genotypes was only observed for the number of leaflets and ALW where Demon produced more leaflets and Hopehely produced higher ALW. However, drought stress significantly affected all foliage characteristics of Demon except LAI, while, no significant effect of drought stress was observed on Hopehely (Table 2).

Variance analysis showed that chlorophyll content varied significantly between genotypes after the flowering stage (58 DAS) while drought stress showed a significant effect on chlorophyll content throughout the experiment. A significant difference was observed for chlorophyll content among leaves, leaflets, and measuring points on leaflets (Table 3).

Table 5. Chlorophyll concentration in different foliage parts of Demon at different water levels

Source of variation		**44 DAS**	**51 DAS**	**58 DAS**	**65 DAS**	**72 DAS**	**79 DAS**
Water level × Compound Leaf	W1 × L3	41.89c	41.74b	40.41a	37.17ab	32.49a	30.63a
	W1 × L4	41.68c	39.55c	39.39ab	35.52c	31.95a	28.26b
	W1 × L5	39.97d	39.25c	38.36b	35.47c	31.02ab	26.56bc
	W2 × L3	46.57a	46.91a	40.49a	37.56a	31.71a	26.23bc
	W2 × L4	46.20ab	46.29a	40.28a	35.57bc	29.70bc	25.53c
	W2 × L5	44.78b	45.99a	38.78b	34.33c	29.23c	23.28d
Water level × Leaflet	W1 × LL1	41.45c	40.24b	40.63a	37.42a	32.93a	30.47a
	W1 × LL2	41.19c	40.22b	39.23bc	35.72bc	32.43a	27.67b
	W1 × LL3	40.89c	40.07b	38.31c	35.02bc	30.10b	27.31b
	W2 × LL1	47.35a	46.99a	40.54a	36.53ab	30.65b	27.13b
	W2 × LL2	46.53a	46.61a	39.54ab	36.38ab	30.24b	24.09c
	W2 × LL3	43.67b	45.60a	39.46a-c	34.55c	29.76b	23.82c
Water level × measuring point	W1 × M1	42.47c	41.57c	40.83ab	37.63a	33.23a	30.15a
	W1 × M2	41.18cd	39.97d	38.78cd	35.92b	31.79ab	28.37ab
	W1 × M3	39.89d	38.99d	38.55cd	34.60bc	30.44bc	26.93bc
	W2 × M1	47.36a	47.63a	41.44a	37.59a	31.65ab	26.89bc
	W2 × M2	45.48b	46.31ab	39.68bc	35.76b	30.19bc	24.87cd
	W2 × M3	44.72b	45.25b	38.42d	34.10c	28.80c	23.28d

Means followed by different letters in the same column are significantly different (5% probability level). W1- 80% water holding capacity (WHC); W2- 50% WHC; L3, L4, L5- 3rd, 4th, 5th compound leaf from the apex respectively; LL1, LL2, LL3; top, first and second leaflet respectively; M1, M2, M3- top middle and bottom measuring point on the leaflet respectively.

Table 6. Chlorophyll concentration in different foliage parts of Hopehely at different water levels

Source of variation		44 DAS	51 DAS	58 DAS	65 DAS	72 DAS	79 DAS
Water level × Compound leaf	W1 × L3	45.25a	45.60a	44.32a	41.33a	35.27a	32.68a
	W1 × L4	44.33ab	44.22ab	43.31ab	39.92ab	33.87ab	30.01b
	W1 × L5	43.89a-c	43.35b	42.38bc	39.01bc	33.17b	29.15b
	W2 × L3	44.66ab	44.79a	41.70cd	38.98bc	33.61ab	28.21bc
	W2 × L4	43.47bc	43.34b	40.26de	38.14c	32.93b	26.51cd
	W2 × L5	42.44c	41.49c	39.96e	37.56c	30.36c	24.67d
Water level × Leaflet	W1 × LL1	46.61a	45.01a	44.14a	41.33a	34.24a	30.76a
	W1 × LL2	45.36a	44.58a	43.09a	39.71ab	34.04a	30.62a
	W1 × LL3	41.49b	43.58ab	42.78ab	39.21bc	34.02a	30.45a
	W2 × LL1	46.03a	43.93ab	41.30bc	39.73ab	33.63a	28.08b
	W2 × LL2	42.95b	42.94b	41.17c	37.80cd	32.61a	25.94c
	W2 × LL3	41.57b	42.74b	39.44d	37.15d	30.66b	25.37c
Water level × measuring point	W1 × M1	44.73ab	46.78a	45.04a	40.20a	36.14a	32.77a
	W1 × M2	44.61ab	44.21bc	43.11b	40.13a	34.27b	30.31b
	W1 × M3	44.12ab	42.17d	41.87bc	39.92ab	31.88d	28.76b
	W2 × M1	45.01a	45.34ab	40.78c	38.50a-c	33.97bc	28.32bc
	W2 × M2	43.44bc	42.86cd	40.62c	38.19bc	32.23cd	26.39cd
	W2 × M3	42.10c	41.41d	40.50c	37.98c	30.69d	24.69d

Means followed by different letters in the same column are significantly different (5% probability level). W1- 80% water holding capacity (WHC); W2- 50% WHC; L3, L4, L5- 3rd, 4th, 5th compound leaf from the apex respectively; LL1, LL2, LL3; top, first and second leaflet respectively; M1, M2, M3- top middle and bottom measuring point on the leaflet respectively.

Table 7. Kendall's Correlations analysis of chlorophyll concentration with tuber yield and foliage characteristics

	Tuber Yield	Chlorophyll concentration	Specific Leaf Weight	No. of Leaves	Total Leaf Area	Leaf Area Ratio
Tuber Yield	1	0.400*	0.483**	-0.252	-0.117	-0.15
Chlorophyll concentration		1	0.35	-0.218	-0.017	-0.117
Specific Leaf Weight			1	-0.235	-0.600**	-0.567**
Number of Leaves				1	0.134	-0.118
Total Leaf Area					1	0.700**

*$p \leq 0.05$, **$p \leq 0.01$

In foliage, significantly higher chlorophyll content was observed for 3rd leaf, 1st leaflet, and top measuring point for both genotypes under control as well as drought condition. Both genotypes produced maximum chlorophyll content at tuber bulking that started reducing afterward. In Demon, sharp reduction takes place after flowering, however, Hopehely maintains its chlorophyll content longer and gradual reduction occurs near senescence. In both genotypes, chlorophyll reduction is first observed in lower compound leaves and leaflets (Table 5 and 6). Correlation analysis showed that tuber yield positively correlated to chlorophyll content and specific leaf weight of leaves. It also showed that chlorophyll content was not affected by other foliage characteristics such as specific leaf weight, specific leaf area, or leaf area ratio (Table 7).

4. Discussion

Potato genotype Hopehely produced significantly higher chlorophyll content compared to Demon. It can be due to variation in the foliage development of genotypes. Hopehely produced fewer but heavier leaves with significantly higher average leaf weight

(ALW), specific leaflet weight (SLW), nitrogen percentage in foliage (N%), and produced significantly higher tuber yield. Larger and heavier leaves have a great boundary layer thickness that helps in heat exchange, reduces water loss, and maximizes photosynthetic activity by maintaining relative water content (Banik et al. 2016) thus increasing chlorophyll content. On the other hand, Demon produced significantly taller plants with more leaflets, hence, higher LAI throughout the experiment. A large number of leaflets in Demon can be due to the availability of more internodes on taller plants (Tadesse et al. 2001) or due to smaller leaflets size as a negative correlation exists between leaf size and leaf numbers (Westoby and Wright, 2003). A positive correlation was also observed between chlorophyll content and SLW. It shows that plants with smaller and lighter leaves produced less chlorophyll content per unit area as compared to larger and heavier leaves.

Results also highlighted that chlorophyll content varies significantly with in the same plant. In both genotypes, chlorophyll content decreases from top to bottom. It can be due to the lower light intensity received by lower leaves and base points of the same leave due to the shading effect. These results are in line with (Björkman, 1968; Ashworth and Svec, 1974) who reported significantly lower chlorophyll content per unit area in leaf base. Plants reached the highest chlorophyll content before flowering as they completed vegetative growth which shows that a high part of absorbed nitrogen was used in chlorophyll production until flowering. Chlorophyll content started decreasing after flowering as plants start assimilating reserves for tuber production (Argenta et al. 2004; Reynolds et al. 2005). Moving towards senescence lower leaves lost chlorophyll content earlier than upper leaves.

Besides genotype, drought stress also showed a significant effect on foliage development and chlorophyll content of genotypes, particularly Demon. Plant height, the number of leaflets, LAI, LAD, and N% were significantly reduced in Demon, however, no significant difference was observed in foliage development of Hopehely. It shows higher drought tolerance of Hopehely that produced higher tuber yield under stress conditions as compared to Demon. These results are in line with (Kebede et al. 2019) who showed genotypic differences in the ability to maintain leaf expansion with increasing drought stress. However, drought stress significantly reduced per unit chlorophyll content of both genotypes throughout the experiment can be the reason for the significant reduction of tuber yield in Hophely under drought stress. It shows that drought stress causes a reduction in per unit chlorophyll content in drought-sensitive as well as drought-tolerant plants.

5. Conclusion

Potato genotype Hopehely produced higher tuber yield under control as well as drought conditions. Hopehely produced the higher chlorophyll content and specific leaf weight under stress conditions. On the other hand, Demon was highly affected by drought stress. This was shown by the reduction in chlorophyll content, foliage nitrogen percentage, leaf area index, number of leaves, and specific leaf weight. Therefore, Hopehely can be used to obtain high yields particularly in areas of water shortage. Drought stress affects chlorophyll concentration in drought-tolerant as well as sensitive genotypes. Although, tuber yield and chlorophyll content correlate positively, yet, it is important to identify the foliage area that truly represents the chlorophyll concentration of the whole plant. In the present study, we observed significant chlorophyll concentration variation in leaves of both genotypes with the top leaflet of 3rd compound leaf from the apex showing the highest chlorophyll concentration. Further studies to determine the relationship between chlorophyll concentration and tuber yield can help in the selection of suitable drought-tolerant genotypes.

Competing Interest Statement: The authors declare that they have no competing interests

List of Abbreviations: Chl, chlorophyll concentration; WHC, water holding capacity; DAS, Days after sowing; ALW, Average leaf weight; SLW, Specific leaf weight; LAI, Leaf area index; LAD, Leaf area duration; NOL, Number of leaves; N%, Nitrogen percentage in foliage; TY, Tuber yield.

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