



Article The Ecophysiological Determinants of Tuber Yield in Response to Potato Genotype and Nitrogen Availability

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Abstract: The cultivar selection and nitrogen (N) fertilization are key management factors to improve potato yield. The aim of the present study was to evaluate the ecophysiological determinants of biomass and tuber yield in potato genotypes in response to N availability under field conditions. Experiments 1 and 2 were carried out in a volcanic soil of southern Chile during the 2021–2022 season. Treatments were applied in the factorial combination of (i) fifteen genotypes of potatoes and (ii) three N fertilization rates (0, 200 and 400 kg N ha⁻¹, 0 N, 200 N and 400 N, respectively). A wide range in total dry matter biomass (5.9–22.1 Mg DM ha^{-1}) and tuber yield (5.1–18.3 Mg DM ha^{-1}) was observed across the experiments. In both experiments, the total biomass and tuber yield were affected by the N rate (p < 0.05) and genotype (p < 0.01), but not by their interaction (p > 0.05). Tuber dry matter yield was strongly related ($R^2 = 0.94$, p < 0.01) to total biomass and weakly related to the harvest index (HI). In both experiments, the total biomass was explained by the radiation use efficiency (RUE) ($R^2 = 0.69-0.75$, p < 0.01). The principal components analysis showed that tuber yield, biomass and RUE were related. The Finlay and Wilkinson analysis revealed that different cultivars varied significantly (p < 0.001) in their sensitivity to N availability. Across environments (3 N rates \times 2 experiments), the most responsive cultivars to N availability were Pukara, Rodeo, Asterix and Patagonia. This information will be useful for potato production systems aimed at improving tuber yield and N use efficiency.

Keywords: RUE; deficiency; N; radiation; Solanum; cultivars

1. Introduction

The potato (*Solanum tuberosum* L.) is the world's fourth most important food crop and a key component of global food security. The current global average of tuber fresh yield is 21 Mg ha⁻¹, which is very low in relation to its potential in many parts of the world [1,2]. Nitrogen (N) fertilization is a key management factor that directly can increase potato yield [3–8]. However, the high N input rates often used raise concerns regarding negative environmental impacts because of N losses into water sources [9–11] and as one of the main sources of greenhouse gas emissions [1,12,13]. Despite the importance of N fertilization in potato crops, few studies have assessed the effects of N on the ecophysiological determinants of tuber yield in response to potato genotypes.

Crop biomass accumulation is strongly related to the amount of radiation intercepted by the crop during the crop cycle [14,15]. Therefore, the tuber dry yield (g m⁻²) of potato crops can be expressed (Equation (1)) as the product of the following three major processes:



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Copyright: © 2023 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https:// creativecommons.org/licenses/by/ 4.0/). intercepted radiation (IR, MJ m⁻²), radiation use efficiency (RUE, g MJ⁻¹) and the harvest index (HI, g g⁻¹) [16,17].

Tuber dry yield =
$$IR \times RUE \times HI$$
 (1)

The total IR by a crop depends on the length of the crop cycle, the fraction of intercepted radiation (FIR) and the daily incident solar radiation (DISR). On the other hand, the FIR depends on the leaf area index (LAI) and the canopy light extinction coefficient (k). Studies in different crops have shown that N and P deficiencies decreased IR because of their direct effect on the LAI [15,18,19]. In potato crops, a reduction in biomass accumulation under water-stress [20], as well as N [21–23] and P deficiencies [17,24], has principally been ascribed to lower IR. Nonetheless, to understand the genotypic variability in relation to N supply, studies assessing the sensitivity of these traits to the N supply in a greater number of genotypes are needed.

The RUE of potatoes ranges from 1.60 to 1.75 g MJ^{-1} (solar radiation basis) [15]. RUE is affected by the genotype and/or environmental conditions [15,25,26]. Genotypic differences in canopy architectures (k coefficient) can affect RUE [27] and have been proven to exist among potato cultivars [26,28]. In several crops, including the potato, RUE has proven to be little affected by P [17–19,24,29]. In contrast, several studies have demonstrated that in many crops RUE has shown a negative response under a N deficiency [15,30]. However, studies on the potato have shown that yield responses to the N supply have mainly been due to increases in IR, while RUE has been little affected [21,31,32]. It has been postulated that the photosynthetic capacity of the potato is insensitive to the N supply [22,33–35]. However, this is in contrast with the results observed for potatoes in Denmark, in which the RUE was decreased in potatoes grown under N deficiency [31]. In addition, recently, it was observed that both IR and RUE explained differences in the dry matter yield of tubers from four potato genotypes [26]. However, no reports have yet assessed RUE in response to different genotypes, N availabilities and the interaction of these two factors.

The potato has shown a higher HI (0.70–0.80) compared to other crops, such as grain crops (0.40–0.50). The HI of the potato is affected by genotype and environmental factors [3,26,36–38]. In general, a N deficiency has proven to increase the HI by, on average, 6–12% [36,37,39]. In addition, it has been found that found that the HI of potatoes (grown in large pots) was slightly affected by different levels of N, P and K [40]. As in other crops (wheat: [18]; maize: [41]), the yield variations of potatoes under different P supplies were ascribed to responses in total biomass production rather than to the HI [17]. All of this evidence suggests that the main source of variation in the tuber yield of potato crops under different N supplies is the total biomass production rather than the HI.

The aim of the present study was to evaluate the ecophysiological determinants of biomass (IR, RUE and HI), tuber yield and the sensitivity of different potato genotypes in response to N availability under field conditions.

2. Materials and Methods

2.1. Site, Experiments and Experimental Design

Two field experiments (Experiments 1 and 2) were conducted at the Austral Agricultural Experimental Station (AAES) of the Universidad Austral de Chile in Valdivia, Chile ($39^{\circ}47'15''$ S, $73^{\circ}14'05''$ W, 19 m a.s.l.), during the 2021–2022 growing season. The experiments were established in the same experimental site and differed in the date of planting. Planting dates were October 7th and November 4th for Experiments 1 and 2, respectively. These planting dates are considered optimal and sub-optimal (late planting) for the potato crop in Chile. The objective of the contrasting planting dates was to expose the crops to different environmental conditions that would produce yield variations. The soil at this site is classified as an Andisol. The soil series is Valdivia (textural class: silty loam) and is characterized by 8, 68 and 24% sand, silt and clay, respectively. Prior to planting, the soil (20 cm depth) had a pH of 5.9 (water (1:2.5)), 9.57% organic matter, 18.9 mg N kg⁻¹ (NO₃ + NH₄) and 10.3 mg kg⁻¹ Olsen P. Exchangeable cations $(\text{cmol}^+ \text{kg}^{-1})$ were 0.23, 0.10, 4.1, 0.39 and 0.01 for K, Na, Ca, Mg and Al, respectively. In each experiment, the treatments resulted from the factorial combination of (i) fifteen genotypes of potatoes and (ii) three N fertilization rates (0, 200 and 400 kg N ha⁻¹, 0 N, 200 N and 400 N, respectively). The genotypes corresponded to commercial cultivars currently planted in Chile (Karu-INIA, Patagonia-INIA, Pukara-INIA, Puyehue-INIA, Yagana-INIA, Asterix, Baraka, Cardinal, Cornado, Desiree, Red Scarlett, Rodeo, Rosara, Shepody and Synfonia). In both experiments (1 and 2), factors were arranged in a split-plot design, where N rates were assigned to main plots and genotypes to sub-plots that were randomized into

2.2. Crop Management

three blocks.

In both experiments, potato seed rates were equivalent to 44,000 seeds ha⁻¹. Each plot consisted of 4 rows that were 4 m long and 0.75 m apart. All plots were fertilized with 220 kg P ha⁻¹ and 300 kg K ha⁻¹. P, K and N rates were distributed and incorporated into each row by hand at planting. The fertilizer sources for N, P and K were Urea (46% N), Triple Super Phosphate (46% P₂O₅) and Muriate of Potash (60% of K₂O), respectively. Both experiments were drip irrigated during the crop cycle (c.a. 350 mm). Weeds, diseases and insects were prevented with the use of herbicides, fungicides and insecticides at the rates recommended by their manufacturers.

2.3. Crop Measurements

Emergence (Em) and physiological maturity (Pm) dates were recorded when 50% of the plants reached these stages at each plot. Spot measurements of the fraction of intercepted radiation (FIR) (the ratio between intercepted and incident solar radiation) were taken during the crop cycle by using three measurements of incident and transmitted solar radiation taken with a ceptometer (1 m long, AccuPAR LP-80) on clear days at noon $(\pm 20 \text{ min})$. Transmitted radiation was measured by placing linear sensors to the left, center and right of the central row of each plot following the green line of the canopy (omitting leaf senescence) [17]. Then, the daily FIR was obtained by interpolation between spot measurements of the FIR over time (by using a polynomial equation previously adjusted to the spot measurements over time). The daily IR (MJ m^{-2}) was calculated as the product of the daily incident solar radiation (DISR) and the daily-calculated FIR. The DISR was directly measured in the meteorological stations located at the AAES. Seasonal RUE (g MJ⁻¹) corresponds to the ratio between the total dry biomass (above-ground biomass plus tuber biomass) and the total accumulated IR during the crop cycle [17]. Climatic data (maximum and minimum temperatures, solar radiation and rainfall) were collected from the Austral weather station located at the AAES.

Aboveground biomass and tuber yield were determined from 3.60 m long samples taken from the two central rows (24 plants) of each plot at physiological maturity (when >70% of the leaves were turning yellow). The fresh weight was measured with a field electronic balance. Fifteen tubers were randomly selected from each plot to determine the dry matter content. An aboveground biomass subsample of 500 g was used to determine the dry matter content. The dry matter weight (DM) of this subsample was then measured on an electronic balance, after oven drying for 48 h at 65 °C. The HI was determined as the ratio between the dry tuber yield and total dry biomass (tuber plus above-ground biomass).

2.4. Statistical Analyses

The statistical analysis was performed with R software 4.1.2 [42], run through the RStudio software [43]. In each experiment, data were analyzed through an analysis of variance for a split-plot design by running the split2.rbd() function available in the ExpDes package [44]. The Fisher's least significant difference test (LSD, p = 0.05) was used to determine the mean comparisons. The linear model for split-plot design is as follows:

$$Y_{ijk} = u + \alpha_i + \gamma_k + (\alpha \gamma)_{ik} + \beta_j + (\alpha \beta)_{ii} + \varepsilon_{ijk}$$

where *Y* is the crop variable, α is the main plot effect, γ is the block term, $\alpha\gamma$ is the main plot error term, β is the sub-plot effect, $\alpha\beta$ is the interaction effect and ε is the subplot error term.

Linear regression models were applied with the lm() function. A principal component analysis (PCA) and Hierarchical cluster analysis were conducted to characterize cultivars and crop traits (prior to the PCA the data from all the variables were standardized). In addition, a Finlay and Wilkinson analysis was performed to characterize cultivars regarding their sensitivities in response to the environmental index. PCA biplots, Hierarchical cluster analysis and a Finlay and Wilkinson analysis were conducted using the fviz_pca_bi()plot available in the factoextra package [45], Factoshiny() fromcthe Factoshiny package [46] and gxeFw() available in the statgenGxE package [47], respectively.

3. Results

3.1. Environmental Conditions during the Crop Cycle

Potato genotypes in Experiment 1 had longer (16%) crop cycles than those in Experiment 2. The average emergence-physiological maturity periods lasted 113 (1588 °C) and 97 (1398 °C) days in Experiments 1 and 2, respectively (Figure 1). The average incident solar radiation was 22.5 and 22.9 MJ m⁻² d⁻¹ in Experiments 1 and 2, respectively (Figure 1). In Experiment 1, the cumulative solar radiation was higher (20%) than in Experiment 2 (2704 vs. 2244 MJ m⁻²). The average air temperatures were 15.7 and 16.4 °C, respectively (Figure 1). During the planting-physiological maturity period, Experiment 1 received less (35%) rainwater (155 mm) than Experiment 2 (239 mm). Additionally, both experiments received 350 mm of water by drip irrigation.



Figure 1. Maximum (red line) and minimum (blue line) air temperatures and cumulative degree days (black line) (upper panel), daily (brown line) and cumulative (orange line) solar radiation (middle panel) and daily (violet line) and cumulative rainfall (blue line) (lower panel) after 1 October 2021. Dashed lines represent the average crop cycle of 15 potato genotypes in Experiments 1 and 2. Em and Pm are the average times of emergence and physiological maturity, respectively.

3.2. Total Biomass and Tuber Yield

A wide range in the total dry matter biomass $(5.9-22.1 \text{ Mg ha}^{-1})$ and tuber yield $(5.1-18.3 \text{ Mg DM ha}^{-1})$ was observed across the experiments. The average tuber yield in Experiments 1 and 2 was 12.7 and 9.5 Mg DM ha⁻¹, respectively. In both experiments, the total biomass and tuber yield were affected by the N rate (p < 0.05) and genotype (p < 0.001), but not by their interaction (Table S1). The tuber dry matter yield increased on average by 15% and 9.6% in treatments N400 and N200 in Experiments 1 and 2, respectively. No differences were observed between the N200 and N400 treatments. In both experiments, the highest tuber yields were reached by Asterix, Cornado and Sinfonía, while the lowest yields were observed for Shepody, Rosara and RedScarlet in Experiment 1 and Patagonia, Yagana and Pukara in Experiment 2 (Table S1). Across experiments, the tuber dry matter yield was strongly related ($R^2 = 0.94$, p < 0.001) to the total biomass (Figure 2a). In contrast, the tuber yield was weakly related to the HI (Figure 2b). In both experiments, the HI was only affected (p < 0.001) by the genotype.



Figure 2. Relationship between tuber yield and total biomass (**a**) and harvest index (**b**) of 15 potato genotypes under three N rates (0, 200 and 400 kg N ha⁻¹) in Experiments 1 and 2 (n = 90).

3.3. Intercepted Solar Radiation and Radiation Use Efficiency

Across experiments, the IR ranged between 887 and 2110 MJ m⁻² (Figure 3). In Experiment 1, the average cumulative intercepted solar radiation was 1670 MJ m⁻² while in Experiment 2 this value was 1284 MJ m⁻² (Figure 3). In Experiments 1 and 2, this trait was only affected by the genotype (p < 0.01) (Table S2). However, in Experiment 1, the variance produced by the genotype effect was 2.3-fold greater than that observed in Experiment 2.

Considering both experiments, the total biomass production was positively related ($R^2 = 0.59$; p < 0.01) to the total IR (Experiment 1 reached higher values for IR and total biomass than Experiment 2). However, in each experiment this relationship was not significant across genotypes (Figure 4a). The slope of the regression represents an average seasonal RUE equivalent to 0.9 g DM MJ⁻¹ m⁻² for both experiments. However, a potential RUE of 1.02 g DM MJ⁻¹ m⁻² was calculated for quantile 95 of the data (dashed line). On the other hand, RUE was only affected by the genotype (p < 0.01) (Table S2). In both experiments, significant relationships ($R^2 = 0.69$ –0.75; p < 0.01) were observed between the total biomass and RUE in all the evaluated genotypes (Figure 4b).



Figure 3. Cumulative intercepted solar radiation (IR) during the crop cycle of 15 potato genotypes under three N rates (0, 200 and 400 kg N ha⁻¹) in Experiments 1 (**upper panels**) and 2 (**lower panels**). LSD: least significant difference values (p = 0.05).



Figure 4. Total biomass in relation to intercepted radiation during the crop cycle (**a**) and seasonal radiation use efficiency (**b**) of 15 potato genotypes. Each data point is averaged across three N rates (0, 200 and 400 kg N ha⁻¹) in Experiments 1 and 2 (n = 15). In (**a**), the segmented line corresponds to the regression performed to the upper 95% of the data (quantile 95).

3.4. Principal Component, Hierarchical Cluster and Finlay and Wilkinson Analyses

In Experiment 1, the PCA analysis revealed that the first two components accounted for 75% of the total variance. This percentage is high, and thus, the first two components were retained for further analyses. PC 1 was dominated by tuber yield, total biomass and RUE, while PC 2 was dominated by the HI and intercepted radiation (Figure 5a). Acute angles between the loading vectors indicate that RUE was strongly positively correlated with productivity traits. Conversely, the HI was strongly negatively correlated with the intercepted radiation (Figure 5a). In Experiment 2, a high variability was accounted for PC 1 and 2, which explained 41 and 32% of the total variability, respectively (Figure 5b)



showing a similar pattern of variables for each component. The genotypes Asterix, Cornado and Synofonía were characterized by high productivity, contrary to Rosara, RedScarlett, Shepody and Yagana.

Figure 5. Biplot from principal components (**upper panel**) and cluster (**lower panel**) analysis for 15 potato genotypes under three N rates (0, 200 and 400 kg N ha⁻¹) in Experiments 1 (**a**,**c**) and 2 (**b**,**d**). In (**a**,**b**), dots represent the individual (cultivar/N rate combinations), and arrows represent the trait factor loading coordinates for radiation use efficiency (RUE), tuber dry matter yield (TuberDM), total dry matter biomass (TotalBioDM), harvest index (HI), intercepted solar radiation (Riacum) and the average fraction of intercepted radiation (FRI) and N rates (Nrate). In (**c**,**d**), groups of treatments in blue, red and green represent clusters 1, 2 and 3, respectively.

The cluster analysis for Experiments 1 (Figure 5c) and 2 (Figure 5d) distinguished three groups of treatments. In Experiment 1, cluster 1 was made of treatments (such as 0 RedScarlett, 0 Rosara, 0 Shepody, 200 RedScarlett and 400 RedScarlett) characterized by low values for RUE, IR, total biomass and tuber yield (Figure 5c). Cluster 2 grouped treatments such as 200 Rosara, 400 Cardinal, 400 Karu, 400 Patagonia, 400 Puyehue, 400 Rosara and 400 Yagana which were characterized by high values for IR and low values for RUE, HI and tuber yield (Figure 5c). Cluster 3 was made of treatments such as 0 Asterix, 0 Synfonia, 200 Asterix, 200 Baraka, 200 Cardinal, 400 Asterix, 400 Cornado and 400 Synfonia which were characterized by high values for RUE, tuber yield, total biomass and FRI (Figure 5c).

In Experiment 2, cluster 1 is made of treatments (such as 0 Patagonia, 0 Pukara, 200 Desiree, 200 Pukara, 200 Rodeo, 400 Desiree, 400 Patagonia, 400 Pukara and 400 Yagana) characterized by high values for IR and low values for RUE, tuber yield, total biomass and HI (Figure 5d). Cluster 2 was made of treatments such as 0 RedScarlett and 400 RedScarlett. This group is characterized by high values for the variable HI and low values for the variables FRI and IR. Cluster 3 was made of treatments such as 0 Cornado, 0 Synfonia, 200 Asterix, 200 Cardinal, 200 Puyehue, 200 RedScarlett, 200 Synfonia, 400 Asterix and 400 Cornado (Figure 5d). This group was characterized by high values for the variables tuber yield, total biomass and RUE.

When the total tuber dry matter yield of all cultivars was analyzed in response to the environmental index (average yield across cultivars for each N rate), the Finlay and Wilkinson analysis revealed significant effect (p < 0.001) of the sensitivities of cultivars to the environments (Tables S3 and S4). The variation of genotype x environments was explained in 52% by the differences in sensitivities among the cultivars. Across environments, the best and most responsive cultivars were Pukara, Rodeo, Asterix and Patagonia. On the other hand, the low responsive cultivars were Shepody, Puyehue, Rosara and Redscarlett (Table S4, Figure 6).



Figure 6. The Finlay and Wilkinson analysis shows the relationship between the tuber dry matter yield of each cultivar and the environmental index calculated as the average tuber dry matter yield across cultivars for each N rate in each experiment (3 N rates \times 2 experiments). Env 1, 2 and 3 represent the treatments 0 N, 200 N and 300 N, respectively in Experiment 1 while the Env 4, 5 and 6 represent the treatments 0 N, 200 N and 300 N, respectively in Experiment 2.

4. Discussion

In the present study, it was hypothesized that the main sources of variation in the tuber yield of potato crops, under different N supplies, are the total biomass production and its ecophysiological determinants (IR and RUE) rather than the HI. As far as we know, this study provides the first assessment of the association among crop variables, genotypes and N availabilities in order to determine genotypic sensitivity across environments. The

environmental conditions of Experiment 1 were close to the best possible potential for potato crops, since the maximum tuber dry matter yield (18.3 Mg DM ha⁻¹) observed for Asterix and Coronado in the 400 N treatment was very close to tuber yields reported in a similar environment under irrigated conditions, around 90 Mg ha⁻¹ (18 Mg DM ha⁻¹) [13]. This is in line with the yield potential calculated with the potato crop simulation model Lintul-potato in southern Chile [12]. Tuber yield decreased by 25% in Experiment 2, which is in line with the 35% reduction reported when the planting date was delayed by one month, which consequently reduced the crop cycle by around 15% [13].

The results of the present study showed considerable yield variability in total biomass and tuber yield as a result of the genotype and N fertilization rate. Tuber yield variability was mainly explained by total biomass production rather than HI. Similarly, previous studies assessing N or P availabilities have shown strong relationships ($R^2 = 0.83-0.89$) between tuber yield and total biomass [7,17]. Additionally, the HI observed in the present study is within the range reported for potato in previous studies [3,39] and is consistent with studies showing little or moderate impact of nutrient deficiencies on the HI (N: [36,37,39], P: [17]). Therefore, the stability of the HI could be considered in potato simulation models attempting to simulate potato yield in response to nutrient supply (e.g., AQUACROP).

The results of this study showed that higher amounts of IR and biomass were reached in Experiment 1 than those observed in Experiment 2. This could be due to the longer crop cycle in Experiment 1 (113 and 97 days in Experiments 1 and 2, respectively), since late planting dates have shown crop cycle reduction of potatoes crops [13,17]. This is in line with the fact that the total potential biomass that can be reached in a given environment is directly related to the amount of radiation intercepted by the crop [14,15,48]. The principal components revealed a high correlation between FIR and IR. However, the total biomass and tuber yield responses across genotypes were explained principally by RUE variations $(0.62-1.09 \text{ g MJ}^{-1}$ on total solar radiation basis). These values were within the range reported in the literature, since RUE variations between 0.5 and 1.8 g MJ⁻¹ (on a total solar radiation basis) have been reported in previous studies comparing different potato genotypes [17,49]. On the other hand, despite the significant effect of N rates on total biomass and tuber yield observed in the present study, the RUE was not affected by the N rate, which could be related to the moderated effects of N treatments observed in both experiments. This could be attributed to the high N supply of volcanic soils of southern Chile due to their high organic matter content, usually more than 12%. Previous studies have shown moderate [50–52] or null [13] effects of N fertilization on these types of soils, even in environments with tuber yields of 90 Mg ha^{-1} . Therefore, our results are in accordance with the postulation that the photosynthetic capacity of the potato is quite insensitive to the N supply since the potato adapts its foliar development to maintain its productivity per unit of leaf area [22,31,33–35], at least under a moderate N deficiency.

The results of the Hierarchical cluster and Finlay Wilkinson analyses showed important differences between the potato genotypes regarding tuber yield sensitivity in response to environments generated by N rates and experiment conditions. Clearly, the cultivars Asterix, Cardinal, Baraka and Cornado showed the highest yield performance across these environments, contrary to cultivars such as Rosara, Shepody, Synfonía and Yagana. The different behavior observed between these groups could be related to genotypic differences in N use efficiency (NUE). NUE can be defined as the product of two components, namely N uptake efficiency and N utilization efficiency, which vary in response to the genotype and environment [3,4,53]. Genotypic variations in NUE have previously been reported in Canada [37,39]; therefore, these potato cultivars may exhibit genetic variation regarding these traits. Hence, further research comparing these cultivars in terms of their N use efficiency and components (N uptake and N utilization efficiency) is required to improve our understanding regarding the crop trait responses observed here.

5. Conclusions

This research demonstrated a wide variation in tuber yield in response to N availability and genotypes, which was explained by the total biomass, but not the HI. In both experiments, the total biomass was explained by the IR. However, across cultivars, the total biomass responses were mainly related to RUE. Both the HI and RUE were not affected by the N availability, suggesting that these variables are conservative under a moderate N deficiency. However, a reduction in RUE could be expected under higher N deficiencies. The genotypes Pukara, Rodeo, Asterix and Patagonia showed the highest yields across the environments, in contrast to Shepody, Puyehue, Rosara and RedScarlett. This information could be useful for potato breeding and management programs aimed at improving the tuber yield and N use efficiency according to cultivar sensitivities (tolerant vs. sensitive genotypes).

Supplementary Materials: The following supporting information can be downloaded at https: //www.mdpi.com/article/10.3390/agronomy13081971/s1, Table S1: Total dry matter biomass (tuber plus aboveground biomass) and tuber dry matter yield of 15 potato genotypes under three N rates (0 N, 200 N and 400 N) in Experiments 1 and 2.* p < 0.05, *** p < 0.001, n.s. p > 0.05; Table S2: Intercepted radiation (MJ m⁻²) and seasonal radiation use efficiency (g DM MJ⁻¹) of 15 potato genotypes under three N rates (0, 200 and 400 kg N ha⁻¹) in Experiments 1 and 2. * p < 0.05, ** p < 0.01, n.s. p > 0.05.Table S3: ANOVA results of Finlay–Wilkinson Analysis for tuber dry matter yield of 15 potato genotypes under six environments (3 nitrogen rates × 2 experiments). ** p < 0.01; Table S4: Ranking of cultivar based on their sensitivity in response to six environments (3 nitrogen rates × 2 experiments) analyzed through the Finlay–Wilkinson Analysis.

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