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Screening Potato Cultivars for Season Cropping by Reliable Methods at Ecological Conditions of Jiroft

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Abstract

In order to investigate the effect of autumn and winter cropping on the growth analysis and tuber yield of different potato cultivars, a split-plot experiment was conducted in the form of a randomized complete block design in 3 replications in in 2019-2020 years. Cropping season in two levels (autumn and winter) was considered as the main factor and potato cultivars in 10 levels, including Concordia, Ottawa, Georgina, Ribera, Coronada, Colomba, Sylvana, Challenger, Atossa and Sante, were considered as sub factor. The results showed for first year, three main components were introduced, which justified 87.269% of the total variations and for second year, fourth main components were introduced, which justified 91.219% of the total variations. First component alone justified 56.154% of the total variance for (No. of nonmarketable tuber/plant, weight of non-marketable, weight percentage of non-marketable tuber and haulm dry weigh), the second component alone justified 20.658% for (dry matter content of tuber and total biomass), the third component 10.456% for (haulm dry weigh), of the relative variance. According to the regression coefficient, a change of one unit in Marketable yield, No. of nonmarketable tuber/plant, Weight of marketable tuber/plant, Weight of non-marketable tuber/plant, Weight percentage of non-marketable tuber, Haulm dry weigh, Total biomass, Biological yield, Biological yield and Harvest index at second year led to a by 0.4174, 0.5119, 0.0806, 0.4564, 0.39, 0.4296, 0.8449, 0.59, 0.2388 and 0.2685 units in first year.

Keywords: Biological yield, Cropping season, Marketable tuber, Potato, Principal component analysis

1. Introduction

The effect of global warming (a temperature increase of 1.3-3.2°C) on potato production is projected to reduce the potential global potato production by 18-32% (without adaptation) and 9-18% (with adaptation) in the 2050s (Hijmans, 2003). One of the most important ways to reduce and adjust the effects of climate change on crop production is to introduce compatible cultivars and suitable planting times for each region (Hijmans et al., 2003). Adaptation of the crop plant to the environmental conditions (which in the first place refers to the appropriate allocation of the growing season to the growing and reproductive periods) is the result of the interaction of the plant's responses to different environmental factors (such as temperature and photoperiod) (Hay and Porter, 2006). A change in the length of the day (photoperiod), which is closely related to the cropping season in each region, has a significant impact on the potatoes growth and development. Under the short days conditions, tuber formation started earlier and also the number of tubers increases and the growth of haulm decreases, but in the conditions of long days tuber formation started later, stolons are longer and the haulm growth increases (Vreugdenhil et al., 2007). The cultivar and its compatibility with the climatic conditions of the planted area are among the most important factors influencing the crops yield (Kang, 2002).

It has been reported that many quantitative and qualitative traits of potatoes are affected by the conditions of the cultivation area, cultivar, farm management, and other inputs (Liu et al., 2007). The production and quality of potato tuber are influenced by several factors, including the cultivar used, temperature (heat and cold) and moisture stresses, and nutritional factors (Aien et al., 2017). Growth analysis as the net accumulation of Photosynth ate over time has been widely used to study factors affecting plant yield and growth (Gardner et al., 1985). To evaluate the growth rate, productivity, and yield level of potatoes, it is important to study the distribution pattern of dry matter among plant parts

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(Nganga, 1982). The relationship between potato yield with crop growth rate, relative growth rate, net absorption rate, leaf area index and environmental factors was studied by (Nganga, 1982) and it was shown that environmental conditions influence the yield by influencing the growth indices. Patil et al (1990) studied the relationship between potato yield and crop growth rate and relative growth rate and stated, there was a close correlation between the investigated indices and yield at 70 days after planting.

Multivariate statistical methods simultaneously assisted in the evaluation of genotypes in terms of several features, used widely in genetic diversity assessments, regardless of the data type being attributed to morphological, physiological, or molecular aspects (Salehi Sardoei et al., 2022). Among these methods, regression and principal component analyses are the most important ones (Mohammadi and Prasanna, 2003) as indicated in several reports on grapevine (Fattahi Moghadam et al., 2002), savory (Fathi et al., 2020), soybean (Majidian et al., 2020), vetch (Dehghani et al., 2020) and sideritis (Lotfi et al., 2020). Evaluations of physiological diversity can facilitate the selection of superior cultivars and contribute to cultivar management (Menzir, 2012).

Potato cultivation in tropical and subtropical regions of Iran is always associated with many temperature challenges in autumn and winter cultivation. Therefore, for tropical regions, due to the limitation of the growing season and the occurrence of heat and cold stresses, it is of great importance to introduce compatible potato cultivars from early to semi-early groups. Potato cultivars should have special characteristics such as early ripening, fast shedding, short dormancy period, high tuber growth rate, and finally high production potential for cultivation in tropical regions (Aien, 2010; Darabi, 2020). The analysis and growth of potato cultivars in different cropping in tropical regions can be a very successful help in the accurate and scientific selection of suitable and compatible potato cultivars for each cropping season, which can be the subject of this research.

2. Materials and Methods

This study was carried out as a split plot experiment based on a randomized complete block design with 3 replications during the autumn and winter seasons of 2019-2020 years, at South Kerman Agricultural Research and Education Center, Jiroft, Iran. In this study, cropping season at two levels including autumn and winter cropping was the main factor, and potato cultivars at 10 levels including Concordia, Ottawa, Georgina, Ribera, Coronada, Colomba, Sylvana, Challenger, Atosa, and Sante were considered as sub factor. The sowing date in autumn season cropping was 10th October and in winter season cropping was 15th January. Rows and plant spacing were maintained at 75 and 20 cm, respectively. Each plot consisted of 6 planting rows with a length of 4 meters. The tubers pre-sprouted, evenly before planting. The required chemical fertilizers were applied based on the soil analysis during the preparation of the planting bed or after planting. Also, poultry manure was applied at a rate of 5 tons/ha, three weeks after emergence. Irrigation was done dropwise using tape.

For growth analysis 1 m^2 in each treatments and replications were harvested at four stages (30, 45, 60 and 90 days after emergence) in autumn and winter cropping. Plant samples were separated into haulm, tubers and roots and then were kept in an oven at 75°C till constant weights were reached. Dry matter of all the plant parts was recorded using an electronic balance. For estimation of percent tuber dry matter, from each treatments 200 g of tubers was diced and oven dried at 80°C to a constant weight.

The analyses of data were carried out using SAS 9.4 statistical programmed and difference between means was compared by Duncan's Multiple Range Test at 5% probability level.

3. Results

The best traits can be chosen based on a variety of components. In the present study, the first component alone justified 56.154% of the total variance for (No. of nonmarketable tuber/plant, weight of non-marketable, weight percentage of non-marketable tuber and haulm dry weigh), the second component alone justified 20.658% for (dry matter content of tuber and total biomass), the third component 10.456% for (haulm dry weigh), of the relative variance. In total, three main components were introduced, which justified 87.269% of the total variations (Table 1).

Table 1 Eigenvectors, eigenvalues and relative and cumulative variances resulted from principal component analysis for first year

Traits	First Component	Second Component	Third Component
Marketable yield	0.022	0.046	0.933
No. of nonmarketable tuber/plant	0.215	0.088	0.088
Weight of marketable tuber/plant	-0.086	0.176	-0.068
Weight of non-marketable tuber/plant	0.213	0.093	0.062
Weight percentage of non-marketable tuber	0.205	0.052	0.058
Haulm dry weigh	0.200	0.124	-0.211

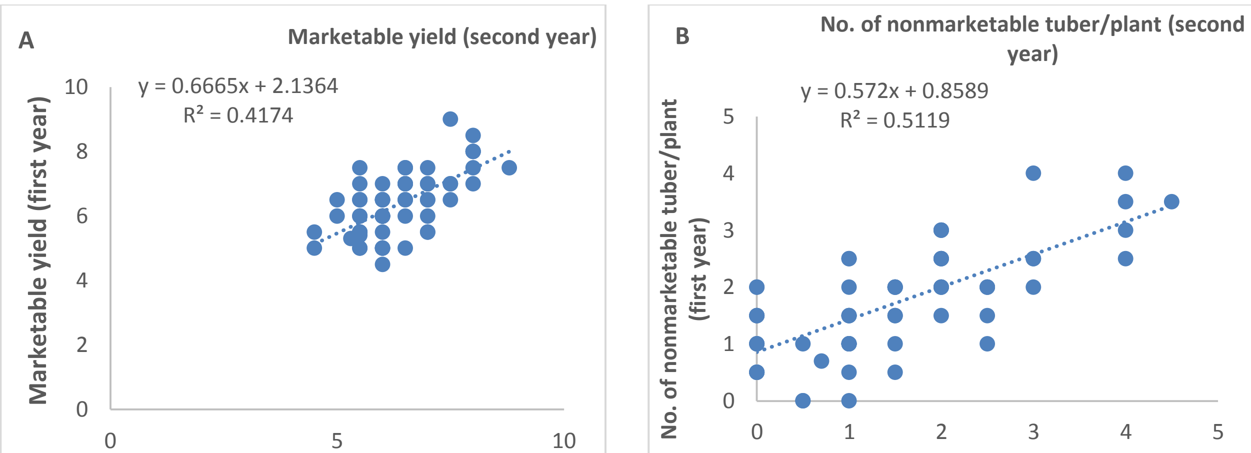
Dry matter content of tuber	0.070	0.364	0.092
Total biomass	0.140	0.437	0.003
Biological yield	-0.075	0.197	-0.032
Harvest index	-0.145	0.091	0.064
Eigenvalue	5.615	2.066	1.045620457
Relative Variance	56.154	20.658	10.456
Cumulative Variance	56.154	76.812	87.269

The best traits can be chosen based on a variety of components. In the present study, the first component alone justified 42.670% of the total variance for (No. of nonmarketable tuber/plant, weight of non-marketable tuber/plant and weight percentage of non-marketable tuber), the second component alone justified 22.223% for (Marketable yield, Weight of marketable tuber/plant and Biological yield), the third component 14.518% for (haulm dry weigh), the fourth Component 11.808% for (dry matter content of tuber and total biomass), of the relative variance. In total, Fourth main components were introduced, which justified 91.219% of the total variations (Table 2).

Table 2 Eigenvectors, eigenvalues and relative and cumulative variances resulted from principal component analysis for second year

Traits	**First Component**	**Second Component**	**Third Component**	**Fourth Component**
Marketable yield	0.157	0.373	0.061	-0.289
No. of nonmarketable tuber/plant	0.350	0.069	-0.089	-0.021
Weight of marketable tuber/plant	-0.010	0.415	0.053	-0.035
Weight of non-marketable tuber/plant	0.343	0.009	-0.065	0.073
Weight percentage of non-marketable tuber	0.326	-0.094	-0.100	0.088
Haulm dry weigh	-0.106	0.106	0.617	0.083
Dry matter content of tuber	0.066	-0.168	-0.102	0.557
Total biomass	0.008	0.165	0.222	0.431
Biological yield	0.007	0.364	-0.038	-0.022
Harvest index	0.082	0.007	-0.475	0.069
Eigenvalue	4.267	2.222	1.452	1.181
Relative Variance	42.670	22.223	14.518	11.808
Cumulative Variance	42.670	64.893	79.411	91.219

Fig. 1, illustrates the changes in second year as affected by changes in Marketable yield (A), No. of nonmarketable tuber/plant (B), Weight of marketable tuber/plant (C), Weight of non-marketable tuber/plant (D), Weight percentage of non-marketable tuber (E), Haulm dry weigh (F), Total biomass (G), Biological yield (H), Biological yield (I) and Harvest index (J) at first year. According to the regression coefficient, a change of one unit in Marketable yield (A), No. of nonmarketable tuber/plant (B), Weight of marketable tuber/plant (C), Weight of non-marketable tuber/plant (D), Weight percentage of non-marketable tuber (E), Haulm dry weigh (F), Total biomass (G), Biological yield (H), Biological yield (I) and Harvest index (J) at second year led to a by 0.4174, 0.5119, 0.0806, 0.4564, 0.39, 0.4296, 0.8449, 0.59, 0.2388 and 0.2685 units in first year, respectively (Fig. 1).



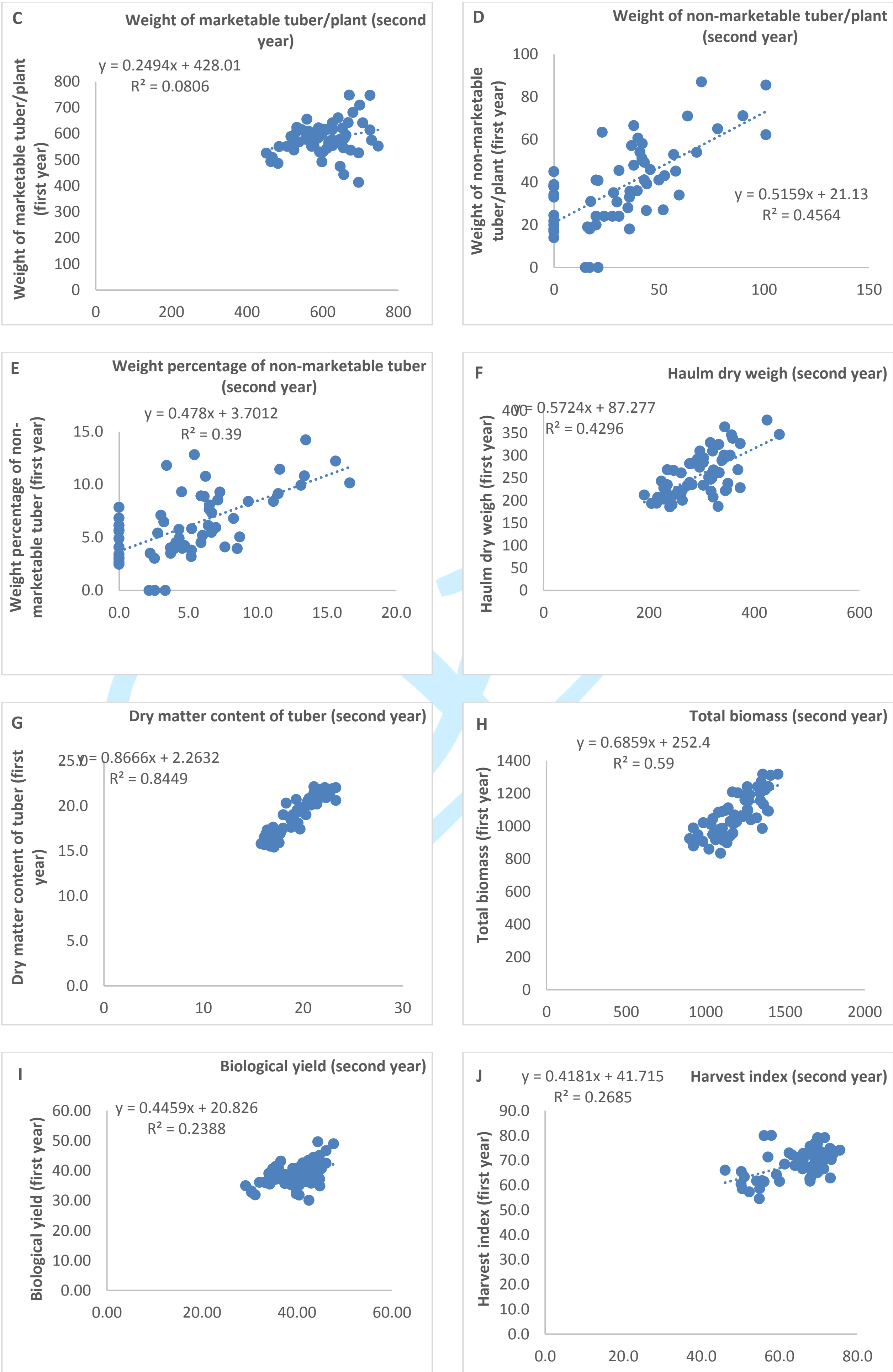


Fig. 1 Results of regression Marketable yield (A), No. of nonmarketable tuber/plant (B), Weight of marketable tuber/plant (C), Weight of non-marketable tuber/plant (D), Weight percentage of non-marketable tuber (E), Haulm dry weigh (F), Dry matter content of tuber (G), Total biomass (H), Biological yield (I) and Harvest index (J) in Potato cultivars

4. Discussion

Regression between traits may assist breeders in indirect selection for stress tolerance via other traits that correlate with the cropping season and are easier to measure (Zahedi et al., 2016; Salehi Sardoei et al., 2023a). Although correlation coefficients between yield traits help to determine correlations with cropping season, they fail to describe the relationships precisely and may require direct or indirect descriptions of the effects between these traits (Zahedi et al., 2016; Moosavi et al., 2016; Salehi Sardoei et al., 2023a). In this study, since many traits correlated significantly and positively with the yield, it is reasonable to further investigate the traits through other statistical methods and determine key traits that affect potato performance. Thus, an integrated Principal component analysis (PCA) was used for a further evaluation of the traits and their effects on potato yield.

At second year, four principal components were identified which described 91.219% of the total variance altogether. The first component included No. of nonmarketable tuber/plant, weight of non-marketable tuber/plant and weight percentage of non-marketable tuber with significantly positive coefficients which described 42.670% of the variance. The second component described 22.223% of the variance. The third component, with significantly negative coefficients. This component alone described 14.518% of the total variance. The fourth component described 11.808% of the variance. Motaghi et al. (2009) and Asgar et al. (2010) used the principal component analysis and reported that the highest variation in data were described by the first two components, concluding that physiology traits described 94% of the variance in stress tolerance. In another study, Zakizade et al. (2010) reported that the first three components described 96% of the total variance.

The best traits may be selected according to different component plots when compared to each other, based on selected components (Sardoei et al., 2022). In most cases, two or three components best describe the variance and are thus used. In the present study, at first year, the first component included No. of nonmarketable tuber/plant, weight of non-marketable, weight percentage of non-marketable tuber and haulm dry weigh, with significantly positive coefficients, which described 56.154% of the total variance. The second component described 20.658% of the variance and the third component, comprising Haulm dry weigh, with significantly negative coefficients, whereas Marketable yield had a significantly positive coefficient. This component alone described 10.456% of the total variance.

In most instances, two or three components which better describe the variance are used (Salehi Sardoei et al., 2023b). Mohi-Ud-Din et al. (2021) used the principle component analysis method andreported that the highest variations in the data are described by the two first components and concluded that physiological traits describe 94 percent of the variance in stress tolerance. In another study, Sarabi and Ghashghaie, (2022) reported that the three firsts components described 96 percent of the total variance altogether.

5. Conclusion

It may be indicated that marketable yield perform better at first year. These traits can be used indirectly in selecting cultivars for select planting.

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Declaration of Conflict

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