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Study Water and Soil Management on Physiology Properties of Potato in Iran

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ABSTRACT

In this study, the cultivation substrate was the main factor (sandy, clayey soil, compost) and drought stress in four control levels and -0.3, -0.6, -1, and -1.5 MPa of soil water potential in three replicates in the form of a split plot. will come First, the physical and texture properties of soils, chemical properties and exchangeable ions, and some biochemical properties of enzymes such as urease are measured. Duncan's test will be used under SPSS conditions to compare the means and relationships between growth components and the effects of drought stress. The evaluated traits include potato yield, plant height, number of plant branches, number of tubers per plant, potato tuber weight average, tuber size, production leaf area. The results have shown that the evaluated traits are significantly influenced by the type of soil texture and water stress and the mutual effect of these two factors. This study showed that different soils will affect water-saving irrigation strategies that are worth knowing for suitable agricultural water management. So, under non-limited water resources conditions, clay sand produces the highest yield under full irrigation but water-saving irrigations are not recommended due to considerable loss (50%) in potato yield. We has conducted that manure and cover crops help increase the organic matter in soils and Good calcium nutrition is important to reduce the impact of stress, not just water stress.

Keywords: Potato; Soil Texture; Drought Stress; Potato Physiology

Introduction

Potato with the scientific name Solanum tuberosum is a plant from the eggplant family that has compound and cut leaves and white or purple flowers. Its fruit is small, spherical, red, round and poisonous. Potato is the fourth most cultivated agricultural product in the world after corn, wheat and rice [1]. Potato production in the world has increased from 270 million tonnes in 1961 to 370 million tonnes in 2019. The increase in production is primarily because of a consistent increase in yield potential of potato cultivars, as the area harvested for potato production decreased from 22.14 million hectares to 17.34 million hectares in the same period. The yield potential of potato cultivars has increased by 58.7% in the last half-century. China, India, Russia, the USA, and Ukraine are the largest potato-producing countries, followed by Poland, Germany, Belarus, Netherlands, and France. Europe is the second-largest potato-producing region (125.43 million tonnes) after Asia (140.6 million tonnes) (Figure 1). In Europe, potato production has reduced from 137.1 million tonnes in 1994 to 107.26 million tonnes in 2019. The highest potato production in Europe was observed during 1996, and has been declining ever since. The main reason for the decrease in tuber production in Europe is the reduction in the harvested area by 51.7% between 1994–2019. In 1994, potatoes were harvested on 9.7 million ha of European land; however, in 2019, only 4.69 million ha of land was used for potato production. Recent FAO stats show [2] that most of the potato production in Europe comes from Eastern Europe (55–61%), followed by Northern Europe (25–29%).

Southern Europe and Western Europe contribute only 6% and 10%, respectively. The potato tuber is a non-photosynthetic organ whose performance depends on the activities of the source and reservoir and genetic factors, leaf area index, fertilization, temperature, soil (physical, chemical and biological properties), light intensity and humidity are involved in it. and have mutual and sometimes misleading effects. The root of the potato plant is scattered and 85% of it is located at a depth of 30 cm, and for this reason, it is sensitive

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to drought stress and requires sufficient moisture in the light soil during the entire growth period (Harris, et al. [3]). Drought stress occurs in the plant when the potential evaporation and transpiration (atmospheric evaporation demand of the plant) exceeds the actual evaporation and transpiration (the capacity and ability of the roots to extract water from the soil). Experiments by scientists have shown that drought stress up to 80 percent of the plant's water requirement, both before and after tuber formation, causes significant differences in potato production. The tuber bulking stage is one of the important stages of potato growth. At this stage, the plant invests most of its resources on newly formed tubers. At this stage, several factors are very important to get a good product. Among them are optimal soil moisture and temperature, availability of sufficient nutrients in the soil and their balance, and resistance to pest and disease attacks. The maturity stage of the tubers is very important for the food. Potatoes contain toxic compounds called glycoalkaloids. The most important of these poisons are solanine and chaconine.

Solanine in potato is determined by the appearance of green color, especially in the cortex under its skin, which is necessary to study it in many soil tissues. Identification, determination and analysis, reserve root performance and shoot fresh weight, number of leaves, number of branches, reserve root weight, reserve root diameter, plant length and reserve root length are of particular importance (Ackerson, et al. [4]). 1977 The importance of the potato as a food source and culinary ingredient varies by region and is still changing (Figure 1): Show botanical composition of potato. It remains an essential crop in Europe, especially Northern and Eastern Europe like the tomato, the potato is a nightshade in the genus Solanum, and the vegetative and fruiting parts of the potato contain the toxin solanine which is dangerous for human consumption. Normal potato tubers that have been grown and stored properly produce glycoalkaloids in negligible amounts (Figure 2), but, if green sections of the plant (namely sprouts and skins) are exposed to light, the tuber can accumulate a high enough concentration of glycoalkaloids to affect human health.

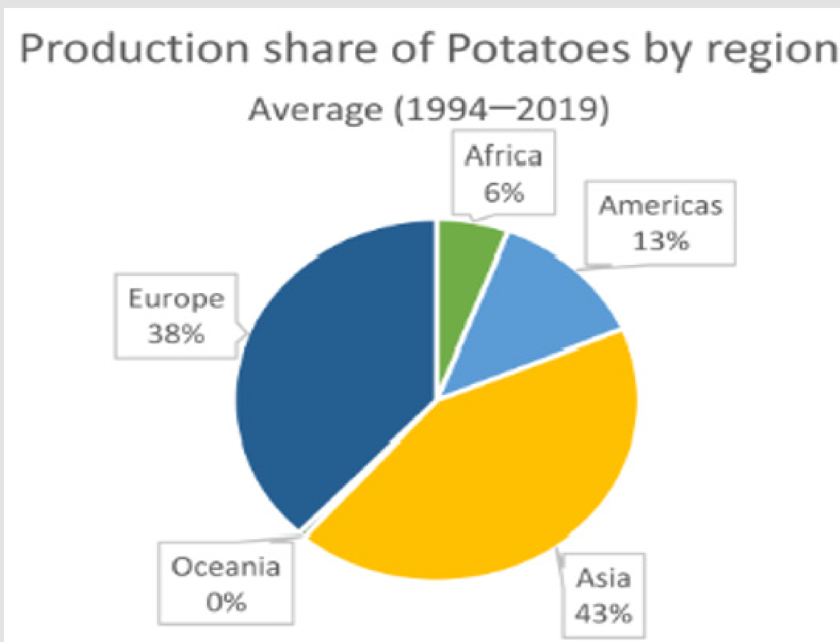

Figure 1: Regional share in potato production during 1994–2019 (FAO 2021).

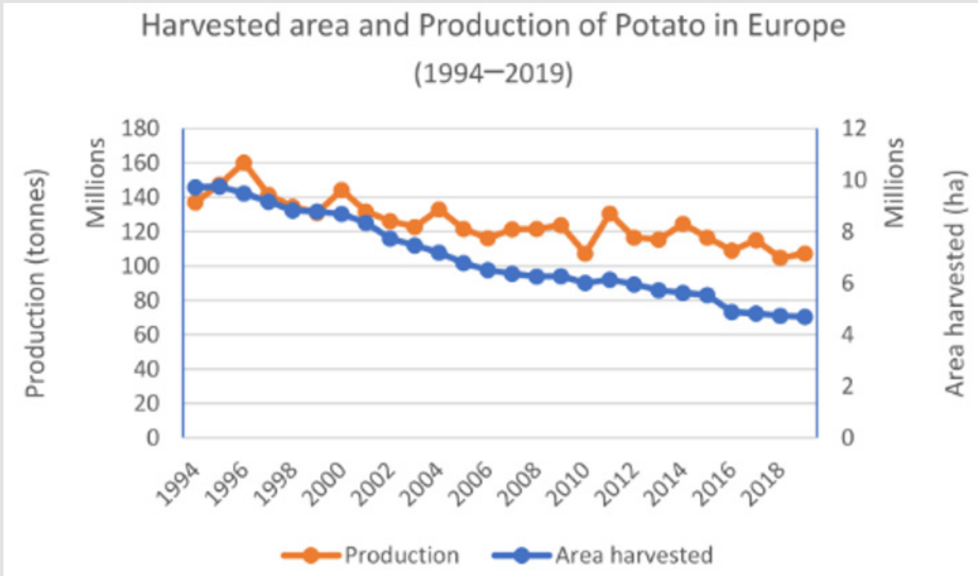

Figure 2: Potato production and area allocated for potato harvest in Europe during 1994–2019(FAO 2021).

Material and Method

An experiment was conducted during 20 december 2023 through March 2024 to assess the effect of planting dates on growth and yield performance of three potential varieties of potato at Semnan university. The experiment was laid out in a randomized complete block design with three replications. In this experiment, seed tubers of potato plants are cultivated in soils with different textures in special plots in March. In this research, the effect of different levels of water stress on yield up to tuber size, percentage of dry matter and number of aerial stems, tuber length, tuber diameter, number of potato tuber are investigated in a split plot design with 3 replications. One of the methods of studying the effects of external factors of heat, humidity, cultivation environment, fertilizers and poisons on photosynthesis is by measuring chlorophylls (a, b) and total carotenoids. In this method, one gram of fresh sample of potato leaves is crushed and ground and mixed and homogenized using 10 ml of 80% acetone. One milliliter of it is selected and mixed with 9 milliliters of 80% acetone and centrifuged for 15 minutes at a speed of 8000 revolutions per minute. Then the supernatant phases are separated to measure chlorophyll a and b and carotenoids. The rest of our work is experimenting with a UV spectrophotometer method. Chlorophyll A and B and total carotenoids are determined at wavelengths of 663, 645, and 480 nm.

Acetone 89% is used as blank and control (white) and the amount of chlorophylls is calculated from the Arnon equation. The amount of carotenoid is calculated using the Gross equation in 1991. Also, the components, number, length and diameter of the potato tuber and the amount of dry matter of the tuber are determined. Identifying the mutual effects of tissue and culture medium and water stress on average tuber weight, tuber size, number of tuber per plant, number of branches per plant, plant height are among the things that have not been studied at the province level and should be studied. Also, what effect do changes in the concentration and amount of NPK elements, soil texture and water stress have on the quantity and quality of potato texture (kheyrodin, et al. [5]).

This is a list of potato varieties or cultivars. Potato cultivars can have a range of colours due to the accumulation of anthocyanins in the tubers (Bradley, et al. [6]). These potatoes also have coloured skin, but many varieties with pink or red skin have white or yellow flesh, as do the vast majority of cultivated potatoes (Bodlaender, et al. [7]) The yellow colour, more or less marked, is due to the presence of carotenoids. Varieties with coloured flesh are common among native Andean potatoes, but relatively rare among modern varieties. They are rarely cultivated because their yield is usually lower than that of improved varieties and are sought after by some amateurs as a curiosity (Table 1). He monovalent potassium K and sodium Na ions of the culture substrate are measured photometrically in the laboratory. Divalent Ca and Mg ions are determined by titration [2]. A number of micro grains of the cultivation bed and heavy metals of the cultivation bed such as Cu, Zn, Ni are also determined by the atomic device.

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Table 1: Different potato varieties cultivated in world (Hijmans, et al. [11]).

Potato varieties	Potato varieties
• *Battata tuberosa* (L. Hill)	• *Solanum stenotomum f. chojllu* (Hawkes)
• *Larnax sylvarum subsp. novogranatensis* (N.W.Sawyer)	• *Solanum stenotomum f. cochicallo* (Hawkes)
• *Lycopersicon tuberosum* (L. Mill.)	• *Solanum stenotomum f. cohuasa* (Hawkes)
• *Parmentiera edulis* (Raf.)	• *Solanum stenotomum f. cuchipacon* (Hawkes)
• *Solanum andigenum* (Juz. & Bukasov)	• *Solanum stenotomum var. cyaneum* (Hawkes)
• *Solanum andigenum convar. acutifolium* (Lechn.)	• *Solanum stenotomum f. eucaliptae* (Hawkes)
• *Solanum andigenum* convar. adpressipilosum (Lechn.)	• *Solanum stenotomum subsp. goniocalyx* ((Juz. & Bukasov) Hawkes)
• *Solanum andigenum f. alccai-huarmi* (Bukasov & Lechn.)	• *Solanum stenotomum f. huallata-chinchi* (Hawkes)
• *Solanum andigenum f. ancacc-maquin* (Bukasov & Lechn.)	• *Solanum stenotomum f. huamanpa-uman* (Hawkes)
• *Solanum andigenum f.* arcuatum (Bukasov & Lechn.)	• *Solanum stenotomum f. huanuchi* (Hawkes)
• *Solanum andigenum subsp. argentinicum* (Lechn.)	• *Solanum stenotomum var. huicu* (Hawkes)
• *Solanum andigenum subsp. australiperuvianum* (Lechn.)	• *Solanum stenotomum f. kamara* (Hawkes)
• *Solanum andigenum subsp. aya-papa* (Bukasov & Lechn.)	• *Solanum stenotomum f. kantillero* (Hawkes)
• *Solanum andigenum var. aymaranum* (Bukasov & Lechn.)	• *Solanum stenotomum var. keccrana* (Hawkes)
• *Solanum andigenum f. basiscopum* (Bukasov & Lechn.)	• *Solanum stenotomum f. kehuillo* (Hawkes)
• *Solanum andigenum f. bifidum* (Bukasov & Lechn.)	• *Solanum stenotomum f.* koso-nahui (Hawkes)
• *Solanum andigenum var. bolivianum* (Bukasov & Lechn.)	• *Solanum stenotomum var. megalocalyx* (Hawkes)
• *Solanum andigenum subsp. bolivianum* (Lechn.)	• *Solanum stenotomum f. negrum* (Hawkes)
• *Solanum andigenum convar. brachistylum* (Lechn.)	• *Solanum stenotomum f. orcco-amajaya* (Hawkes)
• *Solanum andigenum convar. brevicalyces* (Lechn.)	• *Solanum stenotomum f. pallidum* (Hawkes)
• *Solanum andigenum var. brevicalyx* (Bukasov & Lechn.)	• *Solanum stenotomum var. peruanum* (Hawkes)
• *Solanum andigenum convar. brevipilosum* (Lechn.)	• *Solanum stenotomum f. phinu* (Hawkes)
• *Solanum andigenum f. caesium* (Bukasov & Lechn.)	• *Solanum stenotomum f. phitu-huayacas* (Hawkes)
• *Solanum andigenum f. caiceda* (Bukasov)	• *Solanum stenotomum f. piticana* (Hawkes)
• *Solanum andigenum var. carhua* (Vargas)	• *Solanum stenotomum var. pitiquilla* (Hawkes)
• *Solanum andigenum f. ccompetillo* (Bukasov & Lechn.)	• *Solanum stenotomum f. pitoca* (Hawkes)
• *Solanum andigenum f. ccompis* (Bukasov & Lechn.)	• *Solanum stenotomum var. poccoya* (Vargas)
• *Solanum andigenum var. ccusi* (Bukasov & Lechn.)	• *Solanum stenotomum f. puca* (Vargas)
• *Solanum andigenum subsp. centraliperuvianum* (Lechn.)	• *Solanum stenotomum var. puca-lunca* (Hawkes)
• *Solanum andigenum f. cevallosii* (Bukasov & Lechn.)	• *Solanum stenotomum var. putis* (Hawkes)
• *Solanum andigenum f.* chalcoense (Bukasov)	• *Solanum stenotomum f. roseum* (Hawkes)
• *Solanum andigenum f. chimaco* (Bukasov & Lechn.)	• *Solanum stenotomum f. tiele* (Hawkes)
• *Solanum andigenum var. ckello-huaccoto* (Bukasov & Lechn.)	• *Solanum stenotomum f. yana-cculi* (Hawkes)
• *Solanum andigenum f.* coeruleum (Lechn. ex Bukasov)	• *Solanum stenotomum f.* yuracc (Vargas)
• *Solanum andigenum var. colombianum* (Bukasov)	• *Solanum subandigenum* (Hawkes)
• *Solanum andigenum subsp. colombianum* ((Bukasov) Lechn.)	• *Solanum sylvestre* (Audib. ex Dunal)
• *Solanum andigenum f. conicicolumnatum* (Bukasov & Lechn.)	• *Solanum tarmense* (Bukasov)
• *Solanum andigenum f. cryptostylum* (Bukasov & Lechn.)	• *Solanum tascalense* (Brücher)
• *Solanum andigenum convar. curtibaccatum* (Lechn.)	• *Solanum tenuifilamentum* (Juz. & Bukasov)
• *Solanum andigenum var. cuzcoense* (Bukasov & Lechn.)	• *Solanum tuberosum f. acuminatum* (Bukasov & Lechn.)

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• *Solanum andigenum var. digitotuberosum* (Vargas)	• *Solanum tuberosum var. aethiopicum* (Alef.)
• *Solanum andigenum f. dilatatum* (Bukasov & Lechn.)	• *Solanum tuberosum var. alaudinum* (Alef.)
• *Solanum andigenum f. discolor* (Bukasov & Lechn.)	• *Solanum tuberosum var. album* (Alef.)
• *Solanum andigenum subsp. ecuatorianum* (Lechn.)	• *Solanum tuberosum f. alkka-imilla* (Ochoa)
• *Solanum andigenum convar. elongatibaccatum* (Lechn.)	• *Solanum tuberosum f. alkka-silla* (Ochoa)
• *Solanum andigenum f. elongatipedicellatum* (Lechn.)	• *Solanum tuberosum f. amajaya* (Ochoa)
• *Solanum andigenum f. globosum* (Bukasov & Lechn.)	• *Solanum tuberosum subsp. andigenum* ((Juz. & Bukasov) Hawkes)
• *Solanum andigenum var. grauense* (Vargas)	• *Solanum tuberosum var. anglicum* (Alef.)
• *Solanum andigenum f. guatemalense* (Bukasov)	• *Solanum tuberosum f. araucanum* (Bukasov & Lechn.)
• *Solanum andigenum var. hederiforme* (Bukasov)	• *Solanum tuberosum f. auriculatum* (Bukasov & Lechn.)
• *Solanum andigenum var. herrerae* (Bukasov & Lechn.)	• *Solanum tuberosum f. azul-runa* (Ochoa)
• *Solanum andigenum f. huaca-layra* (Bukasov & Lechn.)	• *Solanum tuberosum var. batatinum* (Alef.)
• *Solanum andigenum var. huairuru* (Bukasov & Lechn.)	• *Solanum tuberosum var. bertuchii* (Alef.)
• *Solanum andigenum f. huallata* (Bukasov & Lechn.)	• *Solanum tuberosum var. borsdorfianum* (Alef.)
• *Solanum andigenum f. huaman-uma* (Bukasov & Lechn.)	• *Solanum tuberosum var. brachyceras* (Alef.)
• *Solanum andigenum* var. imilla (Bukasov & Lechn.)	• *Solanum tuberosum f. brachykalukon* (Bukasov & Lechn.)
• *Solanum andigenum f. incrassatum* (Bukasov & Lechn.)	• *Solanum tuberosum f. brevipapillosum* (Bukasov & Lechn.)
• *Solanum andigenum* var. juninum (Bukasov)	• *Solanum tuberosum var. brevipilosum* (Bukasov & Lechn.)
• *Solanum andigenum f. lanciacuminatum* (Bukasov & Lechn.)	• *Solanum tuberosum var.* bufoninum (Alef.)
• *Solanum andigenum f. lapazense* (Bukasov & Lechn.)	• *Solanum tuberosum var. californicum* (Alef.)
• *Solanum andigenum var. latius* (Bukasov & Lechn.)	• *Solanum tuberosum f. camota* (Bukasov & Lechn.)
• *Solanum andigenum f.* lecke-umo (Bukasov & Lechn.)	• *Solanum tuberosum var. cepinum* (Alef.)
• *Solanum andigenum f.* lilacinoflorum (Bukasov)	• *Solanum tuberosum f. chaped* (Bukasov & Lechn.)
• *Solanum andigenum f. lisarassa* (Bukasov)	• *Solanum tuberosum f.* chiar-lelekkoya (Ochoa)
• *Solanum andigenum f. llutuc-runtum* (Lechn. ex Bukasov)	• *Solanum tuberosum f.* chiar-pala (Ochoa)
• *Solanum andigenum convar. longiacuminatum* (Lechn.)	• *Solanum tuberosum subsp. chiloense* ((A.DC.) L.I.Kostina)
• *Solanum andigenum var. longibaccatum* (Bukasov & Lechn.)	• *Solanum tuberosum var.* chiloense (A.DC.)
• *Solanum andigenum convar. macron* (Lechn.)	• *Solanum tuberosum var. chilotanum* (Bukasov & Lechn.)
• *Solanum andigenum f. magnicorollatum* (Bukasov & Lechn.)	• *Solanum tuberosum f.* chojo-sajama (Ochoa)
• *Solanum andigenum var. mexicanum* (Bukasov)	• *Solanum tuberosum var.* chubutense ((Bitter) Hawkes)
• *Solanum andigenum f. microstigma* (Bukasov & Lechn.)	• *Solanum tuberosum f. conicum* (Bukasov & Lechn.)
• *Solanum andigenum convar.* microstigmatum (Lechn.)	• *Solanum tuberosum var. conocarpum* (Alef.)
• *Solanum andigenum f.* nodosum (Bukasov)	• *Solanum tuberosum f. contortum* (Bukasov & Lechn.)
• *Solanum andigenum convar. nudiculum* (Lechn.)	• *Solanum tuberosum f.* coraila (Bukasov & Lechn.)
• *Solanum andigenum convar. obtusiacuminatum* (Lechn.)	• *Solanum tuberosum var. cordiforme* (Alef.)
• *Solanum andigenum f. ovatibaccatum* (Bukasov & Lechn.)	• *Solanum tuberosum var. corsicanum* (Alef.)
• *Solanum andigenum f. pacus* (Lechn. ex Bukasov)	• *Solanum tuberosum f. crassifilamentum* (Bukasov & Lechn.)
• *Solanum andigenum f. pallidum* (Bukasov & Lechn.)	• *Solanum tuberosum var. crassipedicellatum* (Bukasov & Lechn.)
• *Solanum andigenum var. platyantherum* (Bukasov & Lechn.)	• *Solanum tuberosum var. cucumerinum* (Alef.)
• *Solanum andigenum f. pomacanchicum* (Bukasov & Lechn.)	• *Solanum tuberosum var. cultum*
• *Solanum andigenum f. ppacc-nacha* (Bukasov & Lechn.)	• *Solanum tuberosum var. drakeanum* (Alef.)
• *Solanum andigenum f. ppaqui* (Bukasov & Lechn.)	• *Solanum tuberosum var. elegans* (Bukasov & Lechn.)

• *Solanum andigenum convar. puca-mata* (Lechn.)	• *Solanum tuberosum f. elongatum* (Bukasov & Lechn.)
• *Solanum andigenum var. quechuanum* (Bukasov & Lechn.)	• *Solanum tuberosum var. elongatum* (Alef.)
• *Solanum andigenum var. sihuanum* (Bukasov & Lechn.)	• *Solanum tuberosum f. enode* (Bukasov & Lechn.)
• *Solanum andigenum var. socco-huaccoto* (Bukasov & Lechn.)	• *Solanum tuberosum var. erythroceras* (Alef.)
• *Solanum andigenum convar*. stenon (Lechn.)	• *Solanum tuberosum var. fragariinum* (Alef.)
• *Solanum andigenum var. stenophyllum* (Bukasov & Lechn.)	• *Solanum tuberosum var. guaytecarum* ((Bitter) Hawkes)
• *Solanum andigenum f. sunchchu* (Bukasov & Lechn.)	• *Solanum tuberosum var. hassicum* (Alef.)
• *Solanum andigenum subsp. tarmense* (Bukasov & Lechn.)	• *Solanum tuberosum var. helenanum* (Alef.)
• *Solanum andigenum f.* tenue (Bukasov & Lechn.)	• *Solanum tuberosum var. hispanicum* (Alef.)
• *Solanum andigenum f. tiahuanacense* (Bukasov & Lechn.)	• *Solanum tuberosum var. holsaticum* (Alef.)
• *Solanum andigenum convar. titicacense* (Lechn.)	• *Solanum tuberosum f. huaca-zapato* (Ochoa)
• *Solanum andigenum f. tocanum* (Bukasov)	• *Solanum tuberosum f. huichinkka* (Ochoa)
• *Solanum andigenum f. tolucanum* (Bukasov)	• *Solanum tuberosum f. indianum* (Lechn. ex Bukasov)
• *Solanum andigenum f. uncuna* (Bukasov & Lechn.)	• *Solanum tuberosum f. infectum* (Bukasov & Lechn.)
• *Solanum apurimacense* (Vargas)	• *Solanum tuberosum f. isla-imilla* (Ochoa)
• *Solanum aracatscha* (Besser)	• *Solanum tuberosum f. jancck'o-kkoyllu* (Ochoa)
• *Solanum aracc-papa* (Juz. ex Rybin)	• *Solanum tuberosum f. janck'o*-chockella (Ochoa)
• *Solanum ascasabii* (Hawkes)	• *Solanum tuberosum f. janck'o-pala* (Ochoa)
• *Solanum boyacense* (Juz. & Bukasov)	• *Solanum tuberosum var. julianum* (Alef.)
• *Solanum caniarense* (Juz. & Bukasov)	• *Solanum tuberosum var. kaunitzii* (Alef.)
• *Solanum cardenasii* (Hawkes)	• *Solanum tuberosum f. kunurana* (Ochoa)
• *Solanum cayeuxi* (Berthault)	• *Solanum tuberosum f. laram-lelekkoya* (Ochoa)
• *Solanum chariense* (A.Chev.)	• *Solanum tuberosum f. latum* (Bukasov & Lechn.)
• *Solanum chaucha* (Juz. & Bukasov)	• *Solanum tuberosum var. laurentianum* (Alef.)
• *Solanum chaucha var. ccoe-sulla* (Ochoa)	• *Solanum tuberosum var. lelekkoya* (Ochoa)
• *Solanum chaucha var. ckati* (Ochoa)	• *Solanum tuberosum var. leonhardianum* (Alef.)
• *Solanum chaucha var. khoyllu* (Ochoa)	• *Solanum tuberosum f. mahuinhue* (Bukasov & Lechn.)
• *Solanum chaucha var. puca-suitu* (Ochoa)	• *Solanum tuberosum var. malcachu* (Ochoa)
• *Solanum chaucha f. purpureum* (Hawkes)	• *Solanum tuberosum var. melanoceras* (Alef.)
• *Solanum chaucha f. roseum* (Hawkes)	• *Solanum tuberosum var. menapianum* (Alef.)
• *Solanum chaucha var.* surimana (Ochoa)	• *Solanum tuberosum var. merceri* (Alef.)
• *Solanum chiloense* ((A.DC.) Berthault)	• *Solanum tuberosum f. milagro* (Ochoa)
• *Solanum chilotanum* (Hawkes)	• *Solanum tuberosum f. montticum* (Bukasov & Lechn.)
• *Solanum chilotanum var. angustifurcatum* (Lechn.)	• *Solanum tuberosum var. multibaccatum* (Bukasov & Lechn.)
• *Solanum chilotanum f. magnicorollatum* (Lechn.)	• *Solanum tuberosum var. murukewillu* (Ochoa)
• *Solanum chilotanum f. parvicorollatum* (Lechn.)	• *Solanum tuberosum f. nigrum* (Ochoa)
• *Solanum chilotanum var. talukdarii* (Lechn.)	• *Solanum tuberosum var. nobile* (Alef.)
• *Solanum chocclo* (Bukasov & Lechn.)	• *Solanum tuberosum var. norfolcicum* (Alef.)
• *Solanum churuspi* (Hawkes)	• *Solanum tuberosum var. nucinum* (Alef.)
• *Solanum coeruleiflorum* (Hawkes)	• *Solanum tuberosum f. oculosum* (Bukasov & Lechn.)
• *Solanum cultum* ((A.DC.) Berthault)	• *Solanum tuberosum f. ovatum* (Bukasov & Lechn.)
• *Solanum diemii* (E.Brucher)	• *Solanum tuberosum f. overita* (Ochoa)

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• *Solanum dubium* (E.H.L.Krause)	• *Solanum tuberosum var. palatinatum* (Alef.)
• *Solanum erlansonii* (Anon.)	• *Solanum tuberosum var. pecorum* (Alef.)
• *Solanum esculentum* (Neck.)	• *Solanum tuberosum var. peruvianum* (Alef.)
• *Solanum estradea* (L.E.López)	• *Solanum tuberosum f. pichuna* (Bukasov & Lechn.)
• *Solanum goniocalyx* (Juz. & Bukasov)	• *Solanum tuberosum f. pillicuma* (Bukasov & Lechn.)
• *Solanum goniocalyx var. caeruleum* (Vargas)	• *Solanum tuberosum var. platyceras* (Alef.)
• *Solanum herrerae* (Juz.)	• *Solanum tuberosum var. polemoniifolium* (J.Rémy)
• *Solanum hygrothermicum* (Ochoa)	• *Solanum tuberosum var. praecox* (Alef.)
• *Solanum kesselbrenneri* (Juz. & Bukasov)	• *Solanum tuberosum var. praedicandum* (Alef.)
• *Solanum leptostigma* (Juz.)	• *Solanum tuberosum f.* pulo (Ochoa)
• *Solanum leptostigma* (Juz. ex Bukasov)	• *Solanum tuberosum var. putscheanum* (Alef.)
• *Solanum macmillanii* (Bukasov)	• *Solanum tuberosum var. recurvatum* (Bukasov & Lechn.)
• *Solanum maglia var. chubutense* (Bitter)	• *Solanum tuberosum var. reniforme* (Alef.)
• *Solanum maglia var. guaytecarum* (Bitter)	• *Solanum tuberosum var. rockii* (Alef.)
• *Solanum mamilliferum* (Juz. & Bukasov)	• *Solanum tuberosum var. rossicum* (Alef.)
• *Solanum molinae* (Juz.)	• *Solanum tuberosum var. rubrisuturatum* (Bukasov & Lechn.)
• *Solanum oceanicum* (Brücher)	• *Solanum tuberosum var.* rugiorum (Alef.)
• *Solanum ochoanum* (Lechn.)	• *Solanum tuberosum var.* runa (Ochoa)
• *Solanum paramoense* (Bitter ex Pittier)	• *Solanum tuberosum var.* sabinei (A.DC.)
• *Solanum parmentieri* (Molina ex Walp.)	• *Solanum tuberosum var. saccharatum* (Alef.)
• *Solanum parvicorollatum* (Lechn.)	• *Solanum tuberosum var. salamandrinum* (Alef.)
• *Solanum phureja* (Juz. & Bukasov)	• *Solanum tuberosum f. sani-imilla* (Ochoa)
• *Solanum phureja var. caeruleum* (Ochoa)	• *Solanum tuberosum var. schnittspahnii* (Alef.)
• *Solanum phureja var. erlansonii* ((Bukasov & Lechnovitch) Ochoa)	• *Solanum tuberosum f. sebastianum* (Bukasov & Lechn.)
• *Solanum phureja subsp. estradae* ((L.E.López) Hawkes)	• *Solanum tuberosum var. sesquimensale* (Alef.)
• *Solanum phureja var. flavum* (Ochoa)	• *Solanum tuberosum var. sicha* (Ochoa)
• *Solanum phureja subsp. hygrothermicum* ((Ochoa) Hawkes)	• *Solanum tuberosum var. sipancachi* (Ochoa)
• *Solanum phureja var. janck'o-phureja* (Ochoa)	• *Solanum tuberosum var. strobilinum* (Alef.)
• *Solanum phureja var. macmillanii* ((Bukasov & Lechnovitch) Ochoa)	• *Solanum tuberosum f. surico* (Ochoa)
• *Solanum phureja f. orbiculatum* (Ochoa)	• *Solanum tuberosum var. taraco* (Ochoa)
• *Solanum phureja var. pujeri* (Hawkes)	• *Solanum tuberosum var. tener* (Alef.)
• *Solanum phureja var. rubroroseum* (Ochoa)	• *Solanum tuberosum f. tenuipedicellatum* (Bukasov & Lechn.)
• *Solanum phureja var. sanguineum* (Ochoa)	• *Solanum tuberosum f. thalassinum* (Bukasov & Lechn.)
• *Solanum phureja f. sayhuanimayo* (Ochoa)	• *Solanum tuberosum var.* tinctorium (Alef.)
• *Solanum phureja f. timusi* (Ochoa)	• *Solanum tuberosum f.* tinguipaya (Ochoa)
• *Solanum phureja f. viuda* (Ochoa)	• *Solanum tuberosum var.* ulmense (Alef.)
• *Solanum riobambense* (Juz. & Bukasov)	• *Solanum tuberosum var.* versicolor (Alef.)
• *Solanum rybinii* (Juz. & Bukasov)	• *Solanum tuberosum var. villaroella* (Bukasov & Lechn.)
• *Solanum rybinii var. bogotense* (Hawkes)	• *Solanum tuberosum f.* viride (Bukasov & Lechn.)
• *Solanum rybinii var. boyacense* ((Juz. & Bukasov) Hawkes)	• *Solanum tuberosum var. vuchefeldicum* (Alef.)
• *Solanum rybinii var. pastoense* (Hawkes)	• *Solanum tuberosum var. vulgare* (Macloskie)
• *Solanum rybinii var. popayanum* (Hawkes)	• *Solanum tuberosum var. vulgare* (Hook.f.)

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• *Solanum sabinei* ((A.DC.) Berthault)	• *Solanum tuberosum f.* wila-huaycku (Ochoa)
• *Solanum* sanmartinense (Brücher)	• *Solanum tuberosum f. wila-imilla* (Ochoa)
• *Solanum sendigena* (Juz. & Bukasov)	• *Solanum tuberosum f. wila-k'oyu* (Ochoa)
• *Solanum sinense* (Blanco)	• *Solanum tuberosum f. wila-monda* (Ochoa)
• *Solanum stenotomum* (Juz. & Bukasov)	• *Solanum tuberosum f. wila-pala* (Ochoa)
• *Solanum stenotomum f. alcay-imilla* (Hawkes)	• *Solanum tuberosum var. xanthoceras* (Alef.)
• *Solanum stenotomum f. canasense* (Vargas)	• *Solanum tuberosum f. yurac-taraco* (Ochoa)
• *Solanum stenotomum f. canastilla* (Hawkes)	• *Solanum tuberosum var. yutuense* (Bukasov & Lechn.)
• *Solanum stenotomum f.* catari-papa (Hawkes)	
• *Solanum stenotomum f. ccami* ((Bukasov) Hawkes)	
• *Solanum stenotomum var. ccami* (Bukasov)	
• *Solanum stenotomum var. chapina* (Hawkes)	
• *Solanum stenotomum f. chilcas* (Hawkes)	
• *Solanum stenotomum f. chincherae* (Hawkes)	

Results

Analysis variance of the effects of soil texture and water stress on the growth of potato aerial parts present in Tables 2 & 3, Figure 2 has shown that drought stress has a tremendous impact on potato production and its impact depends on the severity and duration of the stress and on the crop growth stage as well. The Table 2 shows the growth stages and the amount of available water required for a high yield of high-quality potatoes. Soil moisture should be above 70 per cent for all stages stress becomes critical when the available soil water drops below 65 per cent [5,8]. This research is carried out in the winter of 1402 in the form of split-plot randomized complete blocks design with three replications in the desert research greenhouse of the Faculty of Desertology of Semnan University. So that the type of cultivation bed as the main factor has three levels (sandy clay soil, clay soil, compost soil) and the sub-factor includes water stress in 4 levels. The results show in Table 2 and Figures 2-5. Soil salinity is one of the important characteristics of arid and semi-arid regions in the world. Salinity and water stress affect plant growth and development. Sweet potato (Ipomoea batatas L.) is a crop with economical importance in the world. Sweet potato is an efficient and low production cost crop that is grown during almost the whole year Under stressful conditions, vegetable plants and their response to drought and salinity are mainly based on the type of species, cultivars, and even landraces.

Table 2: Effect of Water stress and salinity on leaf area and Growth traits potato.

salinity(dS/M	Watering	Cultivar	Dry weight leaves(g)	leafarea (dm^2)	dry Weight tuber roots	Freah Wight tuber roots(g)
2.00	W1	H	20.95	24.34	87.57	365.3
		U	14.50	20.97	78.50	433.3
	W2	H	14.18	18.31	57.40	234.5
		U	12.65	18.12	56.74	302.0
3.00	W1	H	28.58	31.67	60.88	237.3
		U	11.93	16.25	54.20	299.0
	W2	H	15.55	18.20	64.02	249.8
		U	11.93	16.87	70.91	267.3
4.00	W1	H	19.68	23.73	62.70	243.3
		U	12.73	18.50	85.73	353.7
	W2	H	13.30	16.67	62.43	236.0
		U	8.93	13.14	49.31	267.3

Note: H: 'Humnachero' ; 'U: untacip' ; W1: Watering each 2 days; W2: Watering each 4 days

Table 3: Analysis variance of the effects of soil texture and water stress on the growth of potato leaf aerial parts.

Sources of Variation	Df	ss	Ms	FS
Replication	3	2.23	0.7	2.6^{ns}
Soil texture	2	20.8	10	37**
error a	6	1.7	0.2	
main plat	11	24.8		
water stress	3	46	15.3	35**
water stress soil texture interaction	6	242	40.47	92**
error b	27	11	0.4	
subplot	36	399		
total	47	325		
Significant at 1% level	No significant at 5 % level			

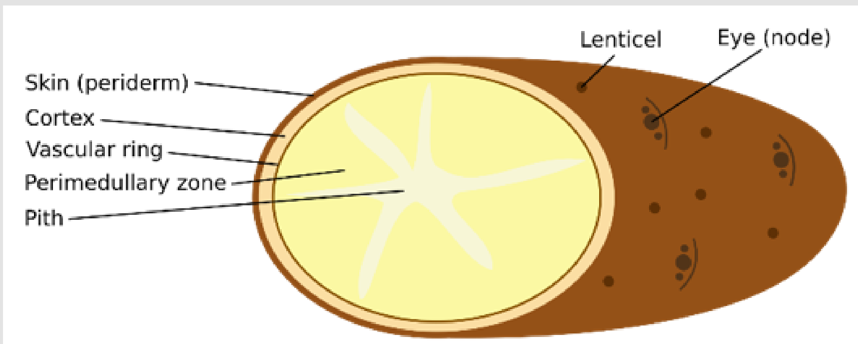

Figure 3: Botanical composition of potato [6].

Figure 4: Potato cultivar experiment in green hous in Semnan university.

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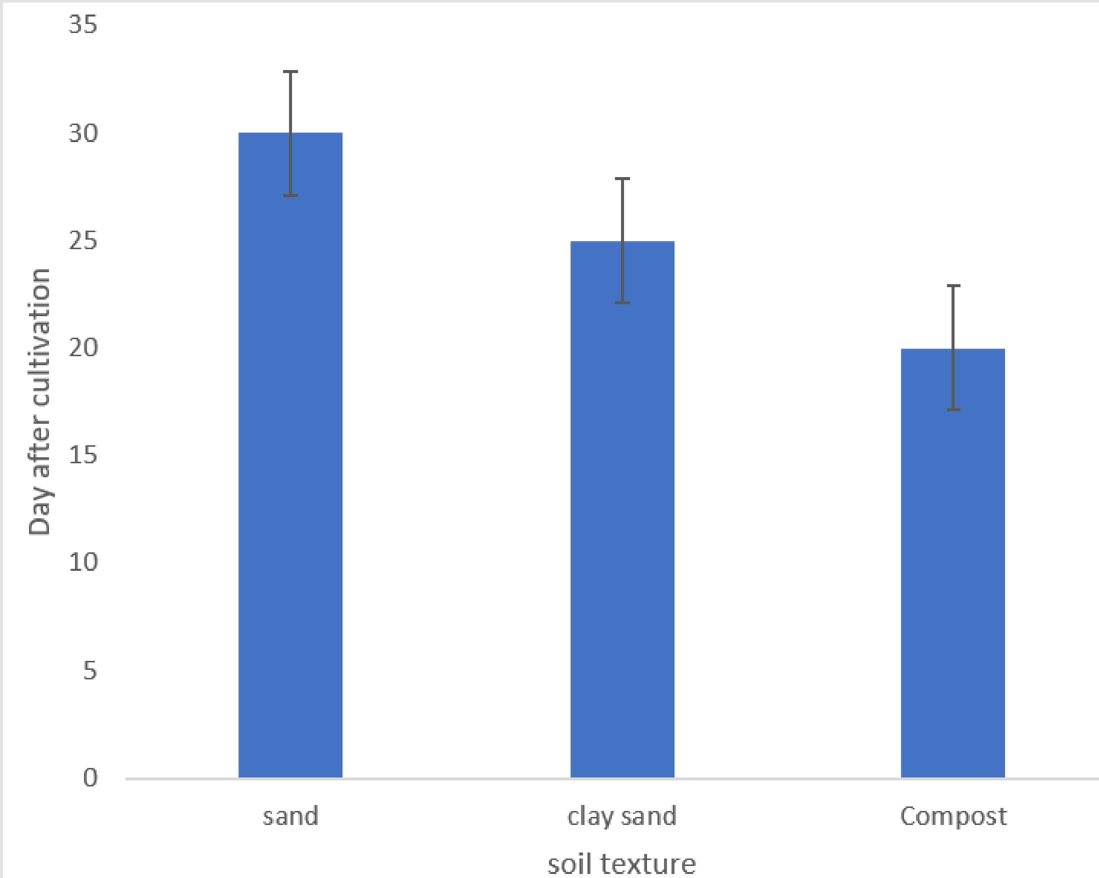

Figure 5: Germination of potato tuber in different soil.

It has been studied that Cl – ions are effective for the catabolism of numerous enzymatic and non-enzymatic activities, and these are also known as co-factors for the regulation of the photosynthesis process. This study show that the K uptake decreased by 28 % when the salinity level increased to 14.0 mmol NaCl. K uptake decreases when plants are grown with high salinity levels, which affects yield. Salinity reduces the ability of plants to take up water, and this quickly causes reductions in growth rate, along with a suite of metabolic changes identical to those caused by water stress. The initial reduction in shoot growth is probably due to hormonal signals generated by the roots (Table 4). The obtained results showed that the length of phenological stages was affected by fertilization and water stress. An increase in animal manure or an increase in irrigation caused acceleration of greening and delay in processing. With the increase of animal manure or the decrease of water, the number of tubers in the plant increased. Tuber weight was not affected by compost, but it increased with increasing planting depth. Tuber performance was affected by compost and water stress. With the increase of compost fertilizer, tuber yield increased and the highest tuber yield (29.01 tons/ha) was obtained from the treatment of 55 tons/ha of fertilizer [6].

Table 4: Analysis variance of the effects of soil texture and water stress on the growth of potato fresh weight roots.

Sources of variation	Df	ss	Ms	Fs
Replication	1	2.23	0.7	2.9^{ns}
Soil texture	2	20.8	10	47**
error a	6	1.7	0.2	
main plat	9	24.8		
water stress	3	46	15.3	45**
water stress soil texture interaction	6	242	40.47	75**
error b	27	11	0.4	
subplot	36	399		
total	46	325		
Significant at 1% level	No significant at 5 % level			

Potato is a comparatively water-efficient crop that produces more calories per unit of water utilized L water is required to produce a kilogram of potatoes, which is significantly less than other globally

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most produced crops (rice, wheat, and maize); these require 1408 L, 1159 L, and 710 L of water to produce a kilogram of rice, wheat, and maize, respectively. Despite high water use efficiency, potato is very susceptible to drought stress (Figure 6). One primary reason is the need for a large amount of irrigated water. Depending upon agro-climatic conditions and soil available water, potato, on average, may require irrigation water between 143 mm to 313 mm. (Bodlaender, et al. [7]), reported that potatoes need 126–381 mm and 212–226 mm irrigation water to achieve potential potato yield in China and India, respectively. In dryer years—such as 2018 in the United Kingdom—the minimum irrigation water requirement increased to 154 mm. They also reported that during dry years in the United States, potatoes use 10 mm water every 24–36 h after flowering to harvesting, making the total irrigation water requirement up to 610 mm. Compared to potatoes, most other crops in Europe require less irrigation water. The irrigation requirement of sugar beet (0–253 mm), cereals (0–82 mm), carrots (0–258 mm), and strawberries (0–132 mm) are significantly less than potato (Table 5).

Table 5: Analysis variance of the effects of soil texture and water stress on the growth of potato dry weight root.

Sources of variation	Df	ss	Ms	FS
Replication	1	3.23	0.7	2.4**
Soil texture	2	30.8	10	2.7**
error a	6	1.7	0.2	
main plat	9	24.8		
water stress	3	46	15.3	45**
water stress soil texture interaction	6	342	40.47	88**
error b	27	11	0.4	
subplot	36	499		
total	46	325		
Significant at 1% level	No significant at 5 % level			

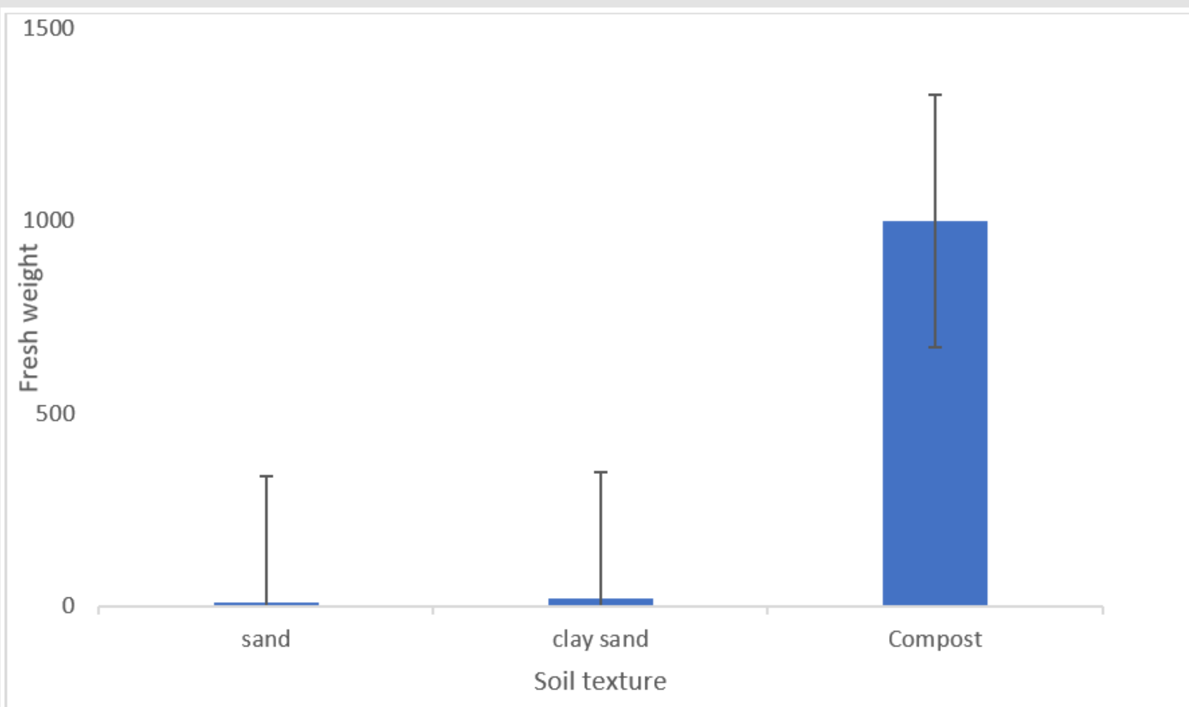

Figure 6: Fresh weight (gr) of aerial part one month after planting potato.

Discussion

Potato is the third most consumed crop globally after rice and wheat. It is a short-duration crop, versatile in use, suitable for growing in a wide range of environments, and its production is increasing rapidly. The modern potato is considered a drought-sensitive crop, and it is susceptible to yield loss because of drought stress Consumption potato production in the North-Western European Potato Growers (NEPG) zone is forecast to fall to 21.2 million metric tonnes, a decline of 6.0% year-on-year (y-o-y), based on current yield estimations. This is attributable to a drop in production in Belgium, France and Germany, which offsets the growth in the Netherlands. Local weath-

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er influences led to a huge variation in yields across the NEPG zone. Yields are estimated to decline by 7.8% y-o-y, to 42.1t/ha in the NEPG zone, with the highest drop in Belgium, estimated down 21.3% y-o-y, to 38.9t/ha. Furthermore, yields fell in Belgium, Germany and France, on the back of adverse summer drought conditions, a critical development period for potatoes. Warmer than average temperatures, combined with a lack of rain, affected the early growth of the potatoes and limited development during bulking before harvest. Potato is a cold-friendly vegetable, except for vegetables. It is a cool season.

One of the important factors in growth and performance Potato is the date of cultivation (Potato Council [8]). Tuber production and quality in potato Under the influence of several factors, including moisture stress, weather and so on Nutrition is determined [8] The effect of temperature fluctuations on growth and Abnormalities of the glands and their unfavorable quality in a certain area Geography is related to the climate characteristics of the region and beyond The power of control is the farmers. But if by adopting the appropriate planting date in Each region can avoid the collision of growth stages with temperature stress It changed the possible conditions in favor of optimal tuber formation in potato (Epstein. and Grant. 1973) (Table 6).

Table 6: Analysis variance of the effects of soil texture and water stress on the growth of potato fresh weight leaves

Sources of variation	Df	ss	Ms
Replication	1	2.23	0.6
Soil texture	2	20.8	10
error a	6	1.7	0.2
main plat	9	24.8	
water stress	3	46	15.3
water stress soil texture interaction	6	242	30.47
error b	27	11	0.4
subplot	36	400	
total	46	323	
Significant at 1% level	No significant at 5 % level		

It is possible to prevent damage to the quality of the production glands At the same time, he also improved the production quantity They stated that due to the delay in planting Our research has shown that potato, the number of tubers increases, but the average weight of the tubers increases decreases) (Chapman, et al. [2]). In the study of the effect of planting date on indices Physiologically, we concluded that leaf area index and speed the growth of CGR and total dry matter is affected by the cultivation date takes. The critical period of growth in the potato plant is its nodulation stage which is the most sensitive to changes in temperature and photoperiod (photoperiod) that can be harvested by choosing the right planting date The above step was prevented by high temperature Results of composite variance analysis of experimental data He said that the effect of planting date and soil texture required time to obtain at least 50% It was significant P ≥0.05. But the effect of water stress and its interactions with soil texture were not significant (Table 7). The average comparison of the obtained data indicates that in Total in the date of planting 20 months in the longest possible time 50% green crop has been achieved. in history December crops, 20 meaningful differences from the point of view 50% green crop did not occur. In this date, plantings in in the shortest time, 50% green crop was obtained [9-13].

Table 7: Analysis variance of the effects of soil texture and water stress on the growth of potato dry weight leaves.

Sources of variation	Df	ss	Ms	FS
Replication	1	6.23	0.6	2.1**
Soil texture	2	20.8	10	2.7**
error a	6	1.7	0.2	
main plat	9	24.8		
water stress	3	46	17.3	45**
water stress soil texture interaction	6	240	33.47	80**
error b	27	11	0.7	
subplot	36	800		
total	46	823		
Significant at 1% level	No significant at 5 % level			

Conclusion

The first response of potatoes to water stress is the closure of leaf stomata, the small pores that control gas exchange between internal leaf cells and the environment Water deficits at tuber initiation reduce tuber set and can increase the proportion of rough, misshapen tubers. Early-season water stress can also reduce specific gravity and increase the amount of jelly-end rot. Water stress during bulking disrupts tuber growth by reducing or stopping tuber expansion. When tuber growth resumes after rain or irrigation, the result is misshapen tubers with cracks, pointed ends and knobs. Water stress during bulking affects total yield more than quality. Tuber bulking slows down for maturation and soil moisture can be reduced. Excessive irrigation will cause soft rot, Pythium leak and enlarged lenticels. After a period of moisture stress, potatoes need time to recover some or all their physiological functions. Consequently, the effect on tuber yield may be considerable. Research has shown that the relationship between the stress parameters Relative Water Content (RWC), leaf water potential (LWP) and stomatal diffusion resistance on the one hand and photosynthesis on the other is discussed. Further it is shown how the amount of water needed by the potato crop depends on climate, soil and plant characters. plants do not recover fully after severe moisture stress.

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