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Intra-Row Spacing on the Growth, Yield and Yield Component of Potato (*Solanium tuberosum* L.): A Review

Arebu Hussen*

Department of Agriculture and Natural Resource, Mekdela Amba University, South Wollo, Ethiopia

**Corresponding author*

Abstract

Potato (*Solanum tuberosum* L.) is a species of flowering plant in the Solanaceae family, native to Chile and Peru. Common names include Chilean potato vine, Chilean nightshade, Chilean potato tree and potato vine. Potato is the fourth most important food crop in the world following rice, corn and wheat. According to legend the first potato for planting purposes in South Africa came from Holland to provide food for mariners visiting the Cape. Since then the potato industry has grown to become one of the important food providers in South Africa. Within the South African context, the gross value of potato production accounts for about 43% of major vegetables, 15% of horticultural products and 4% of total agricultural production. Potato is an herbaceous perennial plant in the family Solanaceae which is grown for its edible tubers. The potato plant has a branched stem and alternately arranged leaves consisting of leaflets which are both of unequal size and shape. The spacing at which you place the seed pieces will determine the harvested potato size. Narrow row plant spacing or optimal in-row spacing can also suppress weeds under certain cropping systems. The destruction of crop residues is important in the management of many pests, such as navel orange worm in almond, late blight of potato, stem rot of rice, and pink bollworm and boll weevil in cotton, for which Row spacing affects competition with weeds.

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Keywords

potato, spacing, growth, yield, yield component.

Introduction

Background and Justification

Potato *(Solanum tuberosum* L.*)* is a species of flowering plant in the Solanaceae family, native to Chile and Peru. Common names include Chileanpotatovine, Chileannightshade, Chileanpotatotree and potatovine. Potato (*Solanum tuberosum* L.) is the fourth most important food crop in the world following rice, corn and wheat (Horton, 1987; FAO, 2008). It is a staple food crop in some countries and in others it is used as vegetable (Mahmood, 2005; Zamil 2010). According to the quantity of production and consumption worldwide, potato is the most important vegetable crop (FAO, 2005; Visker, 2005). In the year 2007 the total volume of world potato production was more than 325.3 million tons that was harvested from the total area of 19.33 million hectare. In the same year in Africa, potato production was 16.71 million tons from 1.54 million hectare (Horton, 1987; FAO, 2008). In the world potato is grown in more than 125 countries (FAO, 2008). It is the second only to Maize in terms of the number of producer countries.

Potato was introduced to Ethiopia in 1858 by the German Botanist, Schemper (Pankhurst, 1964). Now Potato (*Solanum tuberosum* L.) is one of the most important vegetable crops grown in the high and mid altitude areas of Ethiopia. It serves as food and cash crop for small scale farmers, occupies the largest area compared to other vegetable crops and produces more food per unit area and time compared to cereal crops. In 2001 E.C., 0.94 million tons of potato tubers were produced nationally from 164 thousand ha of land (CSA, 2003). The Amhara National Regional State contributed 36.1% of the annual national potato production. However, the regional average potato tuber yield (4.8 t/ha) is less than the national average yield (5.7 t/ha) (CSA, 2003). Factors such as late blight (Phytophto rain festans) and bacterial wilt (Pseudomonas solanacearum) infections, poor crop management and shortage of adaptable and high yielding varieties contributed to the low productivity of potato in the region (Tesfaye and Yigzaw, 2008). The total area under potato production had reached 73,095 ha and the production was estimated to be more than 5.2 million quintals in the year 2007 (MOARD, 2007). Despite these facts, the national average yield of potato is 7.2 t ha^{-1} which is lower than the world's average 16.8 t ha^{-1}. This is attributed to factors such as poor agronomic practices, lack of sustainable supply of improved planting material, high cost of seed tubers, disease and pest problem and inadequate storage (Bereke, 1994). In the mekdela area potato is one of vegetable crops cultivated in the area. Intra row spacing is one factor which influences the growth and yield of potato. Any intra row spacing variation could influence biomass accumulation and subsequently tuber number (Santos and Gilreath, 2004).

Potato ranks fourth important crop in the world. But due to inappropriate management system of production, the yield is below the potential of the crop as well as the farmer or producer can gain. Factors such as poor agronomic practices, lack of sustainable supply improved planting material, high cost of seed tubers; disease and pest problem and inadequate storage are common problems of potato production.

According to Endale and Gebremedhin (2001), the absence of optimal intra row spacing practices could significantly reduce total tuber yield up to 50%. Therefore, optimization of intra row spacing is the one of most important agronomic practices of potato production as it affects the seed cost, plant development and potato tuber yield (Gulluoglu and Arioglu, 2009), so it is important to use proper intra row spacing for potato production.

Objective

To review the effect of intra row spacing on growth, yield and yield component of potato.

Literature Review

Origin and distribution of Potato

According to legend, the first potato for planting purposes in South Africa came from Holland to provide food for mariners visiting the Cape. Since then the potato industry has grown to become one of the important food providers in South Africa. Within the South African context, the gross value of potato production accounts for about 43% of major vegetables, 15% of horticultural products and 4% of total agricultural production. On average domestic potato farmers harvest about R1, 6 billion's worth of potato a year. The latter comprise about 1 700 potato farmers (including approximately 400 seed growers) and 66 600 farm workers. Scientific name: *Solanum tuberosum. Common* names: Table potato, Irish potato Family name: Solanaceae. The potato may be classified as an annual, although it can persist in the field Vegetative (as tubers) from one season to the season. Potato is the second most widely distributed crop in the world after maize. it is grown in about 140 countries of which more than 100 are located in the tropical and subtropical zones (Beukem and Van der Zaag, 1990).in volume of production, potatoes rank fourth after wheat, maize and rice while in the developing world, potatoes have the highest rate of production growth (Cip, 1984). There is evidence abound indicating why the potato should be exploited for the tropics. Potatoes have an incredibly rich and interesting history. For thousands of years, they were cultivated by the Incas in Peru. The earliest archaeological evidence exists on the shores of Lake Titicaca from roughly 400 BCE! Potatoes started quite small and narrow kind of like our fingerlings, just a little gnarlier. The Incas learned how to preserve this durable veggie for storage by dehydrating and mashing them into a substance called chuñu. They could store it for up to 10 years, and it provided great insurance against crop failures. The Incas had a great reverence for potatoes, and thought that they made childbirth easier, as well as used them to treat injuries.

Botanical Description of Potato

Potato, *Solanum tuberosum*, is an herbaceous perennial plant in the family Solanaceae which is grown for its edible tubers. The potato plant has a branched stem and

alternately arranged leaves consisting of leaflets that are both of unequal size and shape. The leaflets can be oval to oblong in shape and the leaves can reach 10–30 cm (4–12 in) in length and 5–15 cm (2–6 in) wide. The potato plant produces white or blue flowers and yellow-green berries. The potato tubers grow underground and generally located in the top 25 cm (10 in) of the soil. The tubers can range in color from yellow to red or purple depending on the variety. Potato plants can reach in excess of 1 m (3.3 ft) in height and are grown as annual plants, surviving only one growing season. Potato may also be referred to as, spud, Irish potato, white potato or Spanish potato and originates from South America. The potato (*Solanum tuberosum*) is a perennial plan the Solanaceae, or nightshade, family, commonly grown for its starchy tuber(*Garden Helper.com, 1997-2020*). Potatoes are the world's most widely grown tuber crop, and the fourth largest crop in terms of fresh produce (after rice, wheat, and m Potato plants have a low-growing habit and bear white to purple flowers with yellow stamens. Potato varieties bear flowers containing asexual parts. Flowers are mostly cross pollinated by other potato plants, including by insects, but a substantial amount of self-fertilizing occurs (*Garden Helper.com, 1997-2020*).

Any potato variety can also be propagated vegetatively by planting pieces of existing tubers, cut to include at least one eye. Some commercial varieties of potatoes do not produce seeds at all (they bear imperfect, single-sex flowers) and are propagated only from tuber pieces. Confusingly, these pieces can bear the name "seed potatoes". After potato plants flower, some varieties will produce small green fruit that look similar to green cherry-tomatoes. These produce seeds like other fruits. Each of the fruits can contain up to 300 true seeds. One can separate seeds from the fruits by putting them in a blender on a slow speed with some water, then leaving them in water for a day so that the seeds will sink and the rest of the fruit will float.

However, some horticulturists sell chimeras made by grafting a tomato plant onto a potato plant, which can produce both edible tomatoes and potatoes. The potato has long been classified as a short-day, cool-season crop, but does very well at high Temperatures when water is supplied in uniform quantities sufficient to meet evapotranspiration demands. The highest yields are currently being produced in areas where the daytime temperature is often over38°C during the hottest part of the growing season and nights are cool 18 °C. Potatoes grow well on a wide variety of soils. In some areas where potatoes are commercially grown the soils are acid, whereas in others they are alkaline. Ideal soil for potato growing is deep, well-drained and friable. High soils in organic matter such as peat or muck, if adequately drained, can also produce high quality potatoes, particularly for the fresh market.

Sandy soils, which contain little clay or little organic matter and have almost no soil structure, when properly irrigated and fertilized, will produce high yields of tubers with excellent culinary and processing quality (Abidin, 2004).

Potatoes are more tolerant to low pH than most other crops. Incidence of common scab tends to be less of a problem where soil pH is lower than 5.4. For cultivars that are susceptible to common scab, the disease is often managed by maintaining soil pH in the range of 5.0 to 5.4. Although potatoes tolerate acid soil, there are benefits from raising the pH of acid soils up to 6.0 to 6, 5 (Engle, 1972).

The potato plant is an herbaceous perennial in that it lacks a woody stem and lives more than two years. It grows 90 to 100 centimeters (3 to 4 feet) tall and is covered with dark green leaves. The above-ground part of the plant dies each winter and regrows in spring. It flowers three to four weeks after sprouting. The flowers are white, pink, or purple with yellow stamens.

After many years of cultivation, the potato has lost much of its ability to produce seeds. Only very rarely does a flower produce a fruit. These are called seed balls and look like small green tomatoes. Each contains up to three hundred seeds, which are sometimes planted in an effort to create new potato varieties. They should not be eaten as they have poisonous substances.

The below-ground part of the potato plant continues to live after the above-ground part has died in winter. Food energy for the next year's growth, in the form of protein and starch, and also water is stored in tubers, called potatoes, which are rhizomes (modified stems) attached to the root system. They are covered by an outer skin called the periderm. Inside that is the cortex, which serves as a storage area for protein and starch. Inside that is the vascular ring that receives starch from the plant's leaves and stem. The starch moves out of the vascular ring to the parenchyma cells that surround it. These cells are the tuber's main storage areas for starch. The pith, which makes up the center of the tuber, is the main area for water storage.

Method of planting

Planting Potato in rows

Dig a shallow trench about 4 inches wide and 6-8 inches deep. The spacing at which you place the seed pieces will determine the harvested potato size.

For most household uses, you will want to plant your potato seeds 15 inches apart in this trench. If you'd like a quick crop of "baby" potatoes for soups and stews, you can plant the seeds 4 inches apart, and begin harvesting them as soon as they reach the desired size. Place the potato seeds into the trench (cut side down) and then cover them with 3-4 inches of soil. Depending on the soil temperature, the sprouts will begin to emerge in about 2 weeks. At this time add another 3-4 inches of soil. Your crop of potatoes will form between the seed piece and the surface of the soil.

For this reason, when the stems are about 8 inches high, you once again add enough soil to bring the level half way up the stem of the plant. Another hilling will be needed 2-3 weeks later, at which time you again add soil half way up the stem of the plant. After these initial hillings, it is only necessary to add an inch or two of soil to the hill each week or so, to ensure there is enough soil above the forming potatoes that they don't push out of the hill and get exposed to light. If the new potato are exposed to sunlight while they are developing, they will turn green. This green portion may be toxic (*TheGardenHelper.com, 1997-2020).*

Potato Mounds

The hilling process is necessary in both methods to create sufficient space for the potatoes to develop large tubers, and an abundant crop. Don't get carried away with hilling though. If you cover up too much of the foliage, you may end up reducing your final crop yield. The basic procedure for planting potatoes in mounds is the same as for planting in rows.

The difference here is that you can grow your crop in a more confined area, or take advantage of an otherwise unused area of the garden. Cultivate and loosen the soil where your potato mound will be designate the approximate perimeter of your planting circle (3-4 feet diameter). Space 6-8 potato seeds evenly around your circle, and cover with the initial 4 inches of soil. Continue the same procedures as you would for planting in rows *(Garden Helper.com, 1997-2020).*

Role of spacing for controlling of weed, disease and pests

Narrow row plant spacing or optimal in-row spacing can also suppress weeds under certain cropping systems. The destruction of crop residues is important in the management of many pests, such as navel orange worm in almond, late blight of potato, stem rot of rice, and pink bollworm and boll weevil in cotton, for which Row spacing affects competition with weeds. Winter wheat is planted in row widths from 6 to 14 inches. Generally, row spacings are wider in the west, where soil moisture is more limited. Wide rows are advantageous when soil moisture is limited because hoe openers can move dry soil to the inter-row without excessive seed coverage. The wheat seeds then are placed into firm moist soil, thereby improving wheat germination, seedling vigor, and crop competitiveness with weeds. When moisture is not a limiting factor, however, narrow rows and increased crop density help with weed control by shading the ground and suppressing further weed germination and development. Narrow row spacing can improve weed control during the fallow periods because weeds are smaller and more easily controlled with herbicides than they are in wide row spacings. Proper spacing and trellising can reduce the occurrence of many vegetable foliar diseases, especially fungal and bacterial diseases that thrive in extended wet periods. Space plants properly to allow good air circulation. Wet conditions are prolonged if plants are crowded and unable to dry quickly. There are compulsory plow-down dates in several regions. Physical suppression tactics may include cultivation or mowing for weed control and temperature management or controlled atmospheres for postharvest pests (Frank, 2001).

Effect of Spacing on tuber yield of potato

Plant seed potatoes 12 inches apart and cover with about 3 inches of soil. When the shoots reach 10 to 12 inches tall, use a hoe or shovel to scoop soil from between rows and mound it against the plants, burying the stems halfway. Repeat as needed through the growing sea. Potato seed-piece and plant spacing often influence how large the average tuber size will be upon maturity. Along with marketplace knowledge, the right combination of environment, growing conditions, cultivar, and sidepiece spacing is essential for maximizing economic yield. The primary factors that determine potato seed-piece spacing are consumer demand, market needs, and the associated economic return to growers and marketers. Other important and often growth-limiting factors include

season length, cultivar, irrigation and nutrient availability and soil type. Row widths generally range from 75 to 91 cm. Although both wider and narrower rows are used. In-row seed-piece spacing is routinely adjusted by growers in an effort to produce the most valuable tuber-size profile for the intended market. Because growing conditions and market needs vary in different regions, seed-piece spacing requirements for particular cultivars are not consistent across the regions. In-row spacing generally ranges from 15 to 35 cm. In-row spacing between18 to 23 cm is probably most common (Tesfaye and Yigzaw, 2008).

Cultivar characteristics like tuber number per plant (tuber set), average tuber-size profile, and days to reach maturity need to be defined prior to selecting the seed-piece spacing. To reduce oversized tubers, cultivars with a low tuber set that tend to produce oversized tubers should be spaced closer together than those with a high tuber set, and vice versa. Wider in-row spacing's may be used to increase average tuber-size when growing late-maturing cultivars in regions having a limited season. Closer in-row spacing may be more desirable when season length, moisture and nutrients are not expected to be limiting factors. Excessively large tubers may develop defects such as hollow heart, knobs, and growth cracks. Reducing the in-row spacing to minimize oversized tuber production may lead to higher quality tubers. Potato starch is used in the food industry as a thickener and binder for soups and sauces, in the textile industry as an adhesive, and for the manufacturing of papers and boards (Jaiand Paul, 2006).

Summary

Potato is an annual, herbaceous, plant belongs to nightshade family, Solanaceae. Any intra row spacing variation could influence biomass accumulation and subsequently tuber numbers. Even if potato ranks fourth important crop many factors such as poor agronomic practice, lack of improved planting material, high cost of tubers, the production and productivity of the crop. Hence, application of appropriate agronomic practices is important to achieve the potential yield of the crop. Narrow row plant spacing or optimal in-row spacing can also suppress weeds under certain cropping systems. A potato is a root vegetable and has large leaves. The part of the potato that people eat is a tuber that grows under the ground. A potato contains a lot of starch and other carbohydrates. Potato usually has a light- brown or yellowish skin and is white or yellow inside. If the potato gets light on it, the tuber turns green and will be poisonous.

Cultivar characteristics like tuber number per plant (tuber set), average tuber-size profile, and days to reach maturity need to be defined prior to selecting the seed-piece spacing. The primary factors that determine potato seed-piece spacing are consumer demand, market needs, and the associated economic return to growers and marketers. Row spacing affects competition with weeds. Winter wheat is planted in row widths from 6 to 14 inches. Generally, row spacing are wider in the west, where soil moisture is more limited.

Future Prospective

It recommended that plant spacing is necessary for good yield. However, we cannot observe the production (yield) parameter because of shortage of time, even though vegetative growths are determined, indicate the production, or yield rate. So, in order to recommend in future, it need to recognize in different factors (soil, agro-ecology, weather, and other agronomical practice with different variety). To get the expected result we will do on spacing of potato planting. When we want to produce potato crop, we should consider the spacing of planting.

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