BIBLIOGRAPHY

SUMALAG, DAVID I. APRIL 2013. Tuber production of Potato Applied with Different Volumes of Water in La Trinidad, Benguet. Benguet State University, La Trinidad Benguet.

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ABSTRACT

The study was conducted to determine the growth and yield of potato applied with different volumes of water;determine the best volume of water for potato production; and to determine the amount of water required at various growth stages of potato.

The different volumes of water applied on the different growth stages significantly affected the plant height, root length, plant vigor at 75DAE, weight of non-marketable tubers and percent survival of the potato plants.

Potato plants applied with 400ml of water during early vegetative stage, 800ml at tuberization to bulking stage and 400ml during the maturity stage per plant produced high percentage of survival, more vigorous plants, high yield, lesser non-marketable tubers, longer roots and lesser malformed tubers as compared to the farmer's practice of800ml of water during early vegetative stage, 800ml at tuberization to bulking stage and 400ml during the maturity stage.

INTRODUCTION

Potato has a great role in the agriculture economy aside from being nutritious. Higher income and production is attained in potato production in a shorter period of time compared to rice production. Also price and demand for potato are more stable as compared to other cash crop vegetables where price fluctuation is very high (NPRCRTC, 1999).

According to Pereira *et al*. (2006) using optimal irrigation strategies with potato can mean a healthy crop with high marketable yield potential. Growers are encouraged to properly manage irrigation by regularly monitoring soil water to ensure that the availability of water does not become a limiting factor in producing a high-yielding potato crop. Also, ensure that the potato crop is well-fertilized and well-protected from pests.

In the Philippines, Benguet and Mountain Province are the major producers of potato (Kalaw, 1987) and irrigation is one of the problems meet because production time is within the dry months wherein availability of water is limited.

At present, excessive and deficit application of water in irrigation is one factor which limits the production of potato in Benguet and other production areas.

As stated by the Department of Primary Industries in Victoria, Australia (2010) potatoes are very sensitive to irrigation. Correct irrigation gives yield responses of around 0.2 tonnes/ha/mm water, which make it highly profitable. Irrigation can also be managed to minimize or prevent some diseases and to produce tubers of the desired quality and size required for specific use. In this case, there is a need to determine the best water requirements of potato at various growth stages which will be useful for successful potato production which this study aims.

In addition, with the climatic change, erratic frequencies of drought and flooding is experienced globally, thus, water management is important to study in irrigation sensitive crops such as potato.

This study was conducted to:

1. determine the growth and yield of potato applied with different volumes of water;
2. determine the best volume of water for potato production; and,
3. determine the amount of water required at various growth stages of potato.

The study was conducted at Benguet State University Experimental Station, Balili La Trinidad, Benguet from November 2012 to February 2013.

REVIEW OF LITERATURE

Effect of Water Stress on Plant

Kramer (1993) stated that water stress affects the aspects of plant growth pertaining to the anatomy, morphology, physiology and biochemistry. So changes in the amount required by the plant may interrupt the normal processes for plant growth such as; keeping cells turgid making stems upright and leaves expanded to receive sunlight for manufacturing and translocation of carbohydrates and nutrients for growth (Tisdale and Nelson,1975); water stress reduces the capacity of protoplasm to carry on photosynthesis, and reduce growth and photosynthesis are both affected by water stress (Ajambar, 1989); Mumns and Pearson (1995) stated that water deficit causes low leaf water potentials leading to decrease in translocation of carbon which is proportional to the decline in photosynthesis and Gabutan (1989) stated that drought affects the total physiological activity through reduction of the net assimilates, also causes early senescence in potato through shortening the bulking period and subsequently lowering the yield.

In addition, water stress may lead to decrease in stomatal opening and lose of turgidity in the guard cells. Eventually, the rate of photosynthesis and consequently growth and yield also decrease where the plant may wilt or die in extreme condition. Moreover, under excess water condition, plant growth is being toxified, and finally retards growth of the plant. It is also said that crops in the early vegetative stage may not develop a deep root system if light watering is done regularly. Also, excessive water affects crop growth as it causes damages to shoots, high incidence of pests and diseases, physical destruction of flowers and less activity of pollinators (AVRDC, 1990).

Irrigation in Potato Production

Irrigation in the era of "best management practices" requires the simultaneous achievement of effective water use for profitable production and environmental protection. Irrigation in excess of crop use should be minimized due to the risk of leaching of nitrate and pesticide residues towards groundwater and the risk of runoff losses of sediment and nutrients to surface water. Excessive irrigation promotes potato diseases. Yet potato is a shallow rooted, water stress sensitive crop. Water deficits reduce tuber yields and quality. Tuber quality parameters that are influenced by water stress include tuber grade, specific gravity, heat necrosis, susceptibility to bruise, hollow heart, translucent-end, jelly end rot, and the dark colour of fried strips and chips. Tuber grade, as determined by shape, smoothness, and freedom from visible defects such as growth cracks, dumbbells, and knobs, is highly sensitive to irrigation management deficiencies. Together these tuber responses to deficit irrigation make potato a challenging crop to irrigate (Pereira and Shock, 2006).

Under irrigation leads to losses in tuber quality, market grade, total yield, and contract price. However, over irrigation leads to erosion, disease susceptibility, water loss, extra energy costs for pumping, nitrogen leaching, and increased in crop nitrogen needs. Excessively wet soil is conducive to many tuber rotting pathogens, encouraging the incidence of blights, rots, and wilts that can limit yield, tuber quality, tuber size, tuber dry matter content, and crop marketability at harvest or from storage. Dense canopy growth, long periods of leaf wetness, and high relative humidity creates microenvironments that favour infection. Improperly managed irrigation often keeps the vines wet for long periods of time, exacerbating the risk of infection (Eldredge*et al.*, 2006).

Irrigation management affects disease severity and management. The increased humidity from irrigation will have greater effects where the macroclimate is humid or sub-humid and be of less importance where it is drier. For potato grown in hot areas, sprinkler irrigation can cool the environment, with possible reductions in physiological defects. However, different irrigation methods can contribute to the occurrence of diseases and pests on the crop depending on site-specific weather pattern. Wet soil is conducive to most tuber-rotting pathogens. Excessive soil moisture following planting can promote seed piece decay and an erratic emergence. Excessive irrigation can also erode hills, thus exposing shallow-set tubers to greening or sunscald and infection by early and late blight pathogens (Rowe and Secor, 1993).

Potato needs to have adequate and consistent soil water during most of its growth stages: sprouting, vegetative, tuber initiation (tuber set), tuber bulking, and maturation growth stages. However, excessively wet soil is conducive to many tuber-rotting pathogens, and excessive moisture on the crop canopy encourages the incidence of foliar blights and wilts that can limit potato performance. Also yield reductions due to over irrigation can be attributed to poor soil aeration, increase susceptibility to rots and diseases, and leaching of nitrogen from the shallow root zone (Eldredge*et al.*, 2006).

Irrigation Requirement in Potato Growth Stages

From emergence to tuber initiation, roots are in the second half of their growth. During this period, the vine grows very rapidly, as much as doubling the canopy every week. With rapidly increasing foliage every week, irrigation starts low, 0.5 inches of irrigation is applied. At tuber initiation, about three weeks after emergence depending on variety, seed health, weather, soil, and cultural practices used, about 1.5 inches of irrigation is applied. A soil moisture of 70 to 80% is preferred, less than 65% field capacity would be considered a deficit. Water deficiency at this point would inhibit canopy and root growth, and indirectly weed control by less ground cover. An excess would retard root branching (development) by water-logging root hairs and promote nitrogen leaching. In short, with an increase in foliage and thereby transpiration, irrigation should begin gradually increase as the canopy grows (University of Nebraska-Lincoln 2012). Also, Water use rates for potato begin at about 0.4 mm per day when the crop sprouts (emerges) and increase to as high as 7 mm per day when the potato canopy completely shades the ground and tubers are bulking. Potato water demand decreases as the crop achieves full tuber bulking and maturation (Efetha, 2011).

According to the University of Nebraska-Lincoln (2012) during tuberization, the first set of tubers is being initiated and these are in slow growth, development stage, the lag phase of tuber growth. Irrigation becomes increasingly important and water stress becomes less tolerable. Transpiration reaches its highest rate. Optimal soil moisture is 80 to 90% field capacity. Irrigation increases from about 1.5 to 2.5 inch per week on sandy type soils. Water deficits would dramatically increase tuber malformations and sugar-ends. It can also weaken plants, promoting early blight. Common scab attack is promoted and the longer the deficit, the greater the attack and more pronounced and enlarge the blemishes.

Also Efetha (2011) stated that potato is most sensitive to water stress during the tuber initiation growth stage; therefore, special care should be taken to start irrigating when soil water in the top half of the root zone (0 to 60-cm depth) is near 70 per cent ofavailable. This practice increases the number of tubers per plant and applying irrigation just before the available soil water is depleted to 70 per cent (i.e. 30 per cent allowable depletion) during tuber initiation and 65 per cent (i.e. 35 per cent allowable depletion) for other growth stages, and replenishing available soil water near field capacity in the root zone will greatly assist in producing a high-quality and high-yielding potato crop. Moreover, according to Eldredge*et al.* (2006), the goal is to ensure that water is available during tuber initiation and in early tuber development by applying light, frequent irrigation. This method promotes vigorous growth and replenishes and increases available soil water content in the entire root zone for later use during the peak water use period, which typically occurs during the flowering and tuber bulking stage.

At tuber bulking, the canopy and roots are fully grown except for indeterminate varieties, which have considerably slowed growth. Tubers are 76 to 82% water and this water must come from the outside, rain or irrigation. Soil moisture should be at 80 to 90% field capacity. This is the period when plants have their highest demand for water and are the most sensitive to deficit. Water deficits here will reduce tuber growth but also there would be increases in tuber malformations, early dying (verticillium and fusarium wilts), early blight and brown spot and common scab. Water excess increases hollow heart, swollen lenticels, black leg, late blight and susceptibility to soft rot, leak and pink rot. Slight moisture stress at this stage will depress yield and this will occur well before any signs such as a darkening of crop colour or wilting of plants can be seen. More severe stresses at this stage will affect tuber shape. Stress early in the bulking up stage will cause some tubers to be pointed like a pear at the stolon end. Stress late in bulking up can cause a point at the rose end. Growth cracks develop if plants are stressed until the time when skins start to become firm late in the bulking up phase, then receive plentiful moisture so that the tubers begin to enlarge again (University of Nebraska-Lincoln 2012). Moreover, Shock *et al.* 2006, soil water should also be maintained between 65 to 100 per cent of available during the tuber bulking growth stage. Soil water levels outside this desirable range at this growth stage will reduce marketable tuber yield and contribute to growth deformities (such as hollow heart, knobbiness, and cracks) and disease development.

During maturity, tuber growth slows and is in the flat stage. As the vine dies, tuber skin sets, hardens and adheres to the tuber core, irrigation decline during this two to five weeks period depending on variety and climate. Soil moisture may decline to 60-65% FC. Excessive irrigation will not only stimulate tuber susceptibility to water rots, soft rot, leak, and pink rot by swelling lenticels but also form an oxygen deprived environment that promotes the pathogens to cause this rots. Also too much water will increase tuber susceptibility to shatter bruise due to raised tuber water content (University of Nebraska-Lincoln, 2012)

Effect of Water Stress in Potato Production

(King and Stark) The stomata on the leaf close under plant water deficits as defence against further water loss. The physical indication is an increase in canopy temperature as a result of reduced evaporative cooling of the leaves. While stomatal closure reduces water loss through the leaves, it also reduces carbon dioxide diffusion into the leaf. This slows photosynthesis, reducing the production of photosynthetic products (starch and sugars) by the plant and their translocation from the leaves to the tubers. Also water deficits reduce plant growth by reducing the internal water pressure in plant cells (turgor pressure) which is necessary for expansion. Reduced vine and leaf growth limits total photosynthetic capacity, while reduced root development limit the plants ability to take up water and nutrients. Water deficits disrupt normal tuber growth patterns by reducing or stopping expansion. Tuber growth resumes following relief of plant water deficits, but the disruption of the normal tuber expansion rate may result in tuber malformations such as pointed ends, dumbbells, bottlenecks, and knobs.

Greatest reduction in haulm growth and yield due to moisture stress occurs when the potato is not irrigated twice for ten days each at the early stages of growth or if subjected to water stress from the 21st to the 40th day after haulm emergence and suspended irrigation when the haulm is ten days old appears to enhance greater yield (Bawang, 1981).

<u>Advantages of Proper Irrigation Management</u>

Bawang (1981) recommended that irrigating potato twice a week from planting up to the 40th day from haulm emergence after which watering will be done once a week will save labor and water cost without reducing the yield. However, Eldredge*et al*. (2006) also stated that applying irrigation just before the available soil water is depleted to 70 per cent (i.e. 30 per cent allowable depletion) during tuber initiation and 65 percent (i.e. 35 per cent allowable depletion) for other growth stages, and replenishing available soil water near field capacity in the root zone will greatly assist in producing a high-quality and high-yielding potato crop.

Proper irrigation scheduling also affects pest management strategies. Soil water decreases the mobility of cutworms and potato tuber moth, protecting the tubers from attack. Careful irrigation management produces little to no nitrate leaching. In silt loam soils, it also can reduce nitrogen fertilization requirements (Eldredge*et al*., 2006).

Jose (2008) stated that irrigation of potato particularly cultivars agria and reculta should be done whenever the soil matric potential reaches 25cb to attain physiological, growth performance, higher yield and dry matter content, low sugar content, and lesser tuber disorders. Also plants under moderate stress were noted to have small to medium leaf area and leaf area index, heaviest roots longest roots and highest relative water content are obtained in sweet potato (Perey, 2012).

Potatoes are very sensitive to irrigation. Correct irrigation gives yield responses of around 0.2 tonnes/ha/mm water, which make it highly profitable. Irrigation can also be managed to minimize or prevent some diseases and to produce tubers of the desired quality and size required for specific use (Department of Primary Industries, Victoria, Australia, 2012).

MATERIALS AND METHODS

The experiment was conducted at BSU-Experimental Station in Balili, La Trinidad Benguet in a greenhouse. Plastic pots with a measurement of 12inches x 15 inches were used which are filled with silt loam soil and 500gms of compost fertilizer. One seed tuber was planted per pot at a depth of 4-5 cm. The study was laid out using Completely Randomized Design (CRD) with 3 replications. Weeding was done to avoid water and nutrient competition on the crop. At 30 DAE, 500g compost fertilizer was hilled up to every pot during hilling up at 30 days after emergence. Irrigation was strictly applied right after emergence where the different volumes of water applied to the different growth stages served as the treatments.Frequency of irrigation was done every after 3 days.

Code	Treatment
800mlVS-800mlTBS-400mlMS	800ml of water will be applied from the 1st day of emergence to 30th day (Vegetative Stage), 800ml at 31st to 75th day (Tuberization and Bulking Stage) and 400ml at 76th to 90th day (Maturity Stage)
600mlVS-600mlTBS-300mlMS	600ml of water will be applied from the 1st day of emergence to 30th day (Vegetative Stage), 600ml at 31st to 75th day (Tuberization and Bulking Stage) and 300ml at 76th to 90th day (Maturity Stage)
400mlVS-400mlTBS-200mlMS	400ml of water will be applied from the 1st day of emergence to 30th day (Vegetative Stage), 400ml at 31st to 75th day (Tuberization and Bulking Stage) and 200ml at 76th to 90th day (Maturity Stage)
400mlVS-800mlTBS-400mlMS	400ml of water will be applied from the 1st day of emergence to 30th day (Vegetative Stage), 800ml at 31st to 75th day (Tuberization and Bulking Stage) and 400ml at 76th to 90th day (Maturity Stage)

Data Gathered

200mlVS-400mlTBS-200mlMS	200ml of water will be applied from the 1st day of emergence to 30th day (Vegetative Stage), 400ml at 31st to 75th day (Tuberization and Bulking Stage) and 200ml at 76th to 90th day (Maturity Stage)

1. Plant vigor. Plant vigor was noted base on the rating Scale by Palomar and Sanico (1994).

Scale	Description	Reaction
1	Plants are weak with few stems and leaves; very pale	Poor vigor
2	Plants are weak with few thin stems and leaves; pale	Less vigorous
3	Plants are better than less vigorous	Moderately vigorous
4	Plants are moderately strong with robust stems	Vigorous
5	Plants are strong with robust stems and leaves; Light to dark green in colour.	Highly vigorous

2. Plant survival (%). This was recorded using formula.

$$\text{Plant survival (\%)} = \frac{\text{No. of plants survived}}{\text{No. of plants emerged}} \times 100$$

3. Initial height. This was measured from the base of the plant at the ground level to the youngest shoots, using a meter stick from five plant samples in different treatments at 20 days after emergence.

4. Final height. This was measured from the base of the plant at the ground level to the youngest shoots, using a meter stick from five plant samples in different treatments at 80 days after emergence.

5. Root length. This was measured from the base to the tip of the roots using a foot rule.

6. Number of days to maturity. Days were counted from emergence to maturity ready for harvesting about 90 % of the haulm is yellowing.

7. Late blight incidence. Late blight was rated using the CIP rating scale (Henfling, 1981).

Score	%Foliage Infected	Description
1	0	0 or very few lesions
3	10	More than 3% but less than 25% foliage infected
5	50	Half of the foliage infected
7	90	More than 75% but less than 97% infected
9	100	Foliage completely infected

8. Marketable yield (g/plant). Marketable tubers were separated and weighed during harvest.

9. Non-marketable yield (g/plant). Tubers that were cracked, green and deformed were separated and weighed during harvest.

10. Total yield (g/plant). This was recorded by getting the total weight of marketable and non-marketable tubers per plant in the different treatments.

11. Malformed tubers per plant (%). This was recorded using the formula:

$$\text{Malformed tubers/plant(\%)} = \frac{\text{No.of malformed tubers}}{\text{Total no. of tubers}} \times 100$$

12. Meteorological Data. The temperature, relative humidity, amount of rainfall and sunshine duration during the study was taken from La Trinidad, Benguet PAGASA station.

Data Analysis

The data were statistically analyzed using the analysis of the variance for completely randomized design (CRD) with 3 replications. The significance of differencesamong the treatment means will be tested using the Duncan's Multiple Range test (DMRT) 5% level of significance.

RESULTS AND DISCUSSION

Agro- Climatic Data during the Study Period

Table 1 shows the temperature, relative humidity, amount of rainfall and bright sunshine during the study period. Temperature ranged from 14.25 to 20.28 ^{0}C, relative humidity is 79.81% and bright sunshine in minute range from 121.18 to 360.

The higher the temperature observed inside the green house, causes higher transpiration rate and evaporation of moisture, thus contributed to water stress of the plants.

Table 1. Agro-climatic data during the study period (November, 2012-February, 2013)

MONTH	TEMPERATURE (^{0}C)		RELATIVE HUMIDITY (%)	BRIGHT SUNSHINE (min)
	MIN	MAX		
NOVEMBER	15.00	27.00	82.00	329.00
DECEMBER	14.00	29.00	75.00	121.18
JANUARY	14.00	26.00	82.00	360.00
FEBRUARY	14.00	27.00	82.00	330.20
MEAN	13.25	27.00	79.81	285.10

Plant Vigor at 30 DAE and 70 DAE

The different volumes of water did not significantly affect the plant vigor at 35 DAE however, significant at 75 DAE (Table 2). Plants applied with 800 ml and 600 ml during the tuberization and bulking stage were moderately vigorous. Observation showed that lesser volumes of water produced plants with poor vigor.

Tisdale and Nelson (1975) stated that changes in the amount required by the plant may interrupt the normal processes for plant growth such as keeping cells turgid making stems upright and leaves expanded to receive sunlight for manufacturing and translocation of carbohydrates and nutrients for growth.

Percent Survival

Table 2 shows that the different volumes of water significantly affected the percent survival of potato. Plants applied with 400 ml, 300 ml and 200 ml during the early and vegetative stage had a hundred percent while the lowest survival was recorded in potato applied with the highest volume of 800 ml.Stem rot was also noted on plants applied with 600ml and 800ml of water. Pereira and Shock (2006) stated that water in excess promotes high incidence of pests and diseases. Also, University of Nebraska-Lincoln (2012) postulated that water excess increases black leg, late blight and susceptibility to soft rot, leak and pink rot.

Table 2. Plant vigor and percent survival as affected by the different water volumes

TREATMENT	PLANT VIGOR		PERCENT SURVIVAL (%)
	35 DAE	70 DAE	
800mlEVS-800mlTBS-400mlMS	5.0	2.87[b]	76.19[c]
600mlEVS-600mlTBS-300mlMS	5.0	2.67[b]	90.47[b]
400mlEVS-400mlTBS-200mlMS	5.0	1.40[a]	100.00[a]
400mlEVS-800mlTBS-400mlMS	5.0	2.93[b]	100.00[a]
200mlEVS-400mlTBS-200mlMS	4.3	1.53[a]	100.00[a]
CV (%)		9.54	4.84

Means with the same letter are not significantly different at 5% level of significance

Figure 1. Potato plant that is infected with stem rot during the early vegetative stage

Initial and Final Plant Height

The application of different volumes of water significantly affected the initial and final heights of the plants as shown in Table 3. On the initial height, plants applied with 800ml of water during the early vegetative stage produced the tallest plants with a mean of 19.07 cm while the shortest were noted on the plants applied with 200 ml with a mean of 15.07 cm. However, in the final height, plants applied with 800 ml and 600 ml during the tuberization and bulking had the tallest with a mean of 42.22 to 42.58. While the application of 400 ml produced shorter plants.

Tisdale and Nelson (1975) revealed that water stress reduces the capacity of protoplasm to carry on photosynthesis. Also Ajambar (1989) stated that reduce growth and photosynthesis are both affected by water stress.

Root length

Significant differences were recorded on the potato root length irrigated withdifferent volumes of water (Table 3). Potato plants applied with the recommended rate (400mlEVS-800mlTBS-400mlMS) had the longest roots of 28.32 cm.

Water deficiency would inhibit canopy and root growth however an excess would retard root branching (development) by water-logging root hairs (University of Nebraska-Lincoln 2012).Moreover, crops in the early vegetative stage may not develop a deep root system if light watering is done regularly (AVRDC, 1999).

Table 3. Plant height and root length applied with different volumes of water

TREATMENT	HEIGHTS (cm)		ROOT LENGTH (cm)
	20 DAE	90 DAE	
800mlEVS-800mlTBS-400mlMS	19.07[a]	42.58[a]	25.77[bc]
600mlEVS-600mlTBS-300mlMS	17.66[b]	42.22[a]	26.72[b]
400mlEVS-400mlTBS-200mlMS	17.75[b]	38.82[b]	25.40[bc]
400mlEVS-800mlTBS-400mlMS	17.53[b]	42.57[a]	28.32[a]
200mlEVS-400mlTBS-200mlMS	15.07[c]	39.11[b]	25.79[bc]
CV (%)	3.67	3.65	2.26

Means with the same letter are not significantly different at 5% level of significance

Number of Days to Maturity

No significant differences were recorded on the number of days to maturity (Table 4). Plants applied with 400 ml of water during tuberization and bulking stage and 200 ml of water from bulking to maturity matured earlier at 87 DAE while application of 600 ml-800 ml during tuberization and bulking stage and 300 ml and 400 ml produced plants that matured later (90 days). This implies that lesser volumes of water affected the maturity of plants.

Gabutan (1989) stated that drought affects the total physiological activity through reduction of the net assimilates, also causes early senescence in potato through shortening the bulking period and subsequently lowering the yield.

Table 4. Number of days to maturity as affected by the different volumes of water

TREATMENTS	NO. OF DAYS TO MATURITY
800mlEVS-800mlTBS-400mlMS	90
600mlEVS-600mlTBS-300mlMS	90
400mlEVS-400mlTBS-200mlMS	87
400mlEVS-800mlTBS-400mlMS	90
200mlEVS-400mlTBS-200mlMS	87
CV (%)	

Reaction to Late Blight

No significant differences were observed on the late blight incidence as affected by the different volumes of water. All plants showed slight infection at 60 DAE until harvest. This could be associated with the method of water application that is directly pouring water in the soil media that reduced free moisture on the foliage and helped to control the late blight.

Marketable Yield

As shown in Table 5, the plants applied with different volumes of water at various growth stages did not significantly affect the weight of marketable tubers per plant. However, potato plants applied with 600 ml and 800 ml during the tuberization and bulking stage had the heaviest weight of marketable tubers with a mean ranging from 313.76 to 324.75g per plant. The least was noted on plants applied with 400 ml during tuberization and bulking stage (268.07g).

Efetha (2011) stated that potato is most sensitive to water stress during the tuber initiation growth stage; therefore, start irrigating when soil water in the top half of the root zone is near 70 per cent ofavailable to assist in producing a high-quality and high-yielding potato crop. Moreover, Shock et *al,* (2006) stated that soil water should also be maintained between 65 to 100 per cent of available water during the tuber bulking stage. Soil water level outside this desirable range will reduce marketable tuber yield and contribute to growth deformities and disease development.

<u>Weight of Non- marketable tubers</u>

Table 5 showed that potato plants applied with the different volumes of water significantly affected the weight of non marketable tubers. Plants irrigated with the recommended rate and 600mlEVS-600mlTBS-300mlMS produced the lowest non-marketable tuber of 3.52 and 5.86 g/plant, respectively, while the application of 400mlEVS-400mlTBS-200mlMS, 200mlEVS-400mlTBS-200mlMS (8.94 g) and the farmers practice had the highest non-marketable tubers.

Tuber quality parameters that are influenced by water stress include tuber grade, specific gravity, heat necrosis, susceptibility to bruise, hollow heart, translucent-end and jelly end rot. Tuber grade, as determined by shape, smoothness, and freedom from visible defects such as growth cracks, dumbbells, and knobs, is highly sensitive to irrigation management deficiencies (Pereira and Shock, 2006). However, excessive moisture promotes potato diseases such as tuber-rotting pathogens as cited by some researchers.

Table 5. Marketable, non-marketable and total yield as affected by the different water volumes

TREATMENT	WEIGHT OF TUBERS (g/plant)		
	MARKET-ABLE	NON MARKETABLE	TOTAL YIELD
800mlEVS-800mlTBS-400mlMS	324.75	8.72[a]	334.54
600mlEVS-600mlTBS-300mlMS	313.76	5.86[b]	319.62
400mlEVS-400mlTBS-200mlMS	278.8	9.17[a]	290.24
400mlEVS-800mlTBS-400mlMS	316.37	3.52[b]	321.54
200mlEVS-400mlTBS-200mlMS	268.07	8.94[a]	280.59
CV (%)	13.17	17.85	14.58

Means with the same letter are not significantly different at 5% level of significance

Total Yield of Potato per Plant

There were no significant differences on the total yield of the potato plants asaffected bythe application of different volumes of water at various growth stages. Mean total yield ranges from 280.59 to 334.54grm per plant.

Percentage of Malformed Tubers per plant

The different volumes of water did not significantly affect the percentage of malformed tubers per plant (Table 5). However, plants applied with 400mlEVS-400mlTBS-200mlMS produced the highest with a mean of 6% followed by 200mlEVS-400mlTBS-200mlMS with a mean of 5 % while plants applied with the recommended rate (400mlEVS-400mlTBS-200mlMS) produced the least with a mean of 1.03 %.

(King and Stark, 1997) Reduced root development limit the plants ability to take up water and nutrients. Water deficits disrupt normal tuber growth patterns by reducing or stopping expansion. Tuber growth resumes following relief of plant water deficits, but the disruption of the normal tuber expansion rate may result in tuber malformations such as pointed ends, dumbbells, bottlenecks, and knobs.

Table 6.Percentage of malformed tubers per plant as affected by the different volumes of water

TREATMENT	AVERAGE NUMBER OF TUBER / 5 PLANTS		MALFORMED TUBERS (%)
	TOTAL	MALFORMED	
800mlEVS-800mlTBS-400mlMS	38.35	1.07	2.80
600mlEVS-600mlTBS-300mlMS	36.65	0.47	1.27
400mlEVS-400mlTBS-200mlMS	30.00	1.80	6.00
400mlEVS-800mlTBS-400mlMS	36.65	0.37	1.03
200mlEVS-400mlTBS-200mlMS	31.65	1.57	4.97
CV (%)	18.05		74.6

Figure 2 . Malformed and cracked tubers more observed on plants applied with lesser volumes of water

SUMMARY, CONCLUSION AND RECCOMENDATION

Summary

This study was conducted at BSU Experimental Station in a greenhouse condition from November 2012 to February 2013 to determine the growth and yield of potato applied with different volumes of water; best volume of water for potato production and the amount of water required at various growth stages of potato.

The different volumes of water significantly affected the plant height, root length, plant vigor at 75 DAE, number of days to maturity, weight of non-marketable tubers and percent survival of the potato plants. Other data recorded showed no significant differences.

Application of 400mlEVS-800mlTBS-400mlMS, 800mlEVS-800mlTBS-400mlMS and 600mlEVS-600mlTBS-300mlMS produce plants that are taller, more vigorous and higher yield and normal number of days to mature.

In terms of the plant survival, application of 400mlEVS-800mlTBS-400mlMS, 200mlEVS-400mlTBS-200mlMS and 400mlEVS-400mlTBS-200mlMS had a 100% survival.

In the root length, longest root is obtained from plants applied with 400mlEVS-800mlTBS-400mlMS.

Conclusion

Application of 400mlEVS-800mlTBS-400mlMS or the recommended rate shows more benefit compared to the other treatments as it produced plants with high yield, lesser non-marketable tubers, high percentage of survival, more vigorous, longer roots which can be an advantage in case of water scarcity, and plants with normal time of maturity.

Recommendation

Application of 400mlEVS-800mlTBS-400mlMS per plant is suited for potato production or 800mlEVS-800mlTBS-400mlMS (farmers practice) could be reduced during the 1^{st} to 30^{th} DAE on silt loam soils.

Further evaluation is recommended to verify the results of the study under open field.

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