BIBLIOGRAPHY

TATPI-IC, JOEMAR T. APRIL 2012. Growth and Yield of Bush Snap Bean (*Phaseolus vulgaris* L.) Varieties Irrigated with Different Levels of Water in La Trinidad, Benguet. Benguet State University, La Trinidad, Benguet.

Adviser: Janet P. Pablo, MSc.

ABSTRACT

The study was conducted at Benguet State University experimental area, La Trinidad Benguet to determine the growth and yield of bush snap bean varieties; determine the growth and yield of bush snap bean as affected by different levels of water; and to determine the interaction effect of the different bush bean varieties under different levels of water.

Results showed that Blue Lake have the highest plant height at 40 DAP and 60 DAP, more flowers, clusters and pods, longest and widest pod, highest number of roots and longest tap root length, highest marketable pods, gross income, net income and ROCE.

The different levels of water significantly affected plant height, length and width of the pods, the length of the tap roots, and weight of the pods, total yield, gross income, net income and ROCE of the three bush snap bean varieties.

The results showed that the application of 20 liters of water and Blue Lake produced the longest pods and longest roots.

INTRODUCTION

Bush snap Bean *(Phaseolus vulgaris* L.) is grown extensively in tropical as well as sub-tropical parts of the world. Bush bean is grown for their tender and green pods or seeds. It is commercially grown in the highlands of cordillera. They are considered as one of the leading farm crops in Benguet and Mountain Province and it is one of the most nourishing of all vegetables. The crop is grown for its economic value and also for its nutrients as it is an important source of fibers, riboflavin and niacin as well as some phosphorous, calcium and iron (Loakan, 2003). It is a good source of vitamin A, C, K, folate and potassium. They're grown commercially for both fresh pod and seed production (Singha, 1973).

The common bean species is not very tolerant to severe water stress. About 60% of the yield loss is reported from drought, making it second only to disease as a grain yield reducer. Some management practices, like irrigation, can contribute to the increase of grain yield under water stress conditions, thus the development of tolerant cultivars becomes an efficient and economical production strategy (White 1994).

In addition, Liu (2010) stated that leguminous crops have the ability to fix nitrogen biologically from the atmosphere. This can benefit not only on the legumes themselves but also any intercropped or subsequent crops, thus reducing or removing the need to apply nitrogen fertilizers.

At present, farmers are planting bush snap bean for both fresh pod and seed production. Sometimes when water is scarce during dry season, farmers grow other crops that require lesser amount of water such as pechay, onion and those that are early maturing and drought resistant.

In this case, the research would like to evaluate potential varieties of beans which are able to withstand different levels of water application in La Trinidad, Benguet condition.

This study was conducted to:

determine the growth and yield of the different bush bean varieties;

determine the growth and yield of bush snap bean varieties applied with different water levels; and

determine the interaction effect of the different bush bean varieties under different levels of water.

The study was conducted at Balili, La Trinidad, Benguet in an open field from December 2011 to February 2012.

REVIEW OF LITERATURE

The Plant

Bush snap bean varieties belong to Leguminosae family which is dwarf and determinate plant. Varieties of bush snap bean are dwarf and that does not require trellis for support due to its determinate growth habit and early maturing. Bush snap bean is a warm temperate season annual crop grown for fresh pods, which are harvested while they are still tender with white seeds, flat or oval and stringless pods are preferred for the fresh market. On the other hand, round-podded varieties with white seeds are preferred for canning (Purseglove, 1978).

He also stated that in temperate countries, the green immature pods are cooked and eaten as vegetables. Immature pods are marketed fresh, frozen or canned whole-cut, or French-cut. In some parts of the tropics, leaves are used as potherb and to a lesser extent, the green shelled beans are eaten.

Environmental Requirement of Bush Bean

Bean grows best in areas with a temperature of up to 25 degrees Celsius (PCARRD, 1989 as cited by Bantog, 1983).

Halfacre and Barden (1980) stated that green bean has two critical times for water needs during bean development-blooming and pod formation. It utilizes 0.20 and 0.16 inches per day. Most often, soils that are weekly irrigated are the best, but sandy and sandy loam soils may need irrigation after every 3 to 5 days.

They also pointed that bush beans and other bean type are characterized to be planted in a soil temperature of at least 16 degrees Celsius to ensure germination.

Most legumes require a slightly acidic soil ranging from pH of 5.2-6.8. poor soil conditions may cause stunting, chlorosis and poor pod setting. A high relative humidity is also essential to maintain a good quality of pod. Moreover, sites for bush bean production are best suited in high places of east Africa, West Africa, Caribbean, South and Central America and Tropical Asia.

Water Supply from Soil to Plants

Water is the cornerstone of agricultural production. If supplies are short, crop production is materially reduced and under severe conditions of drought will completely lose. The nature of the root system is very important in relation to the available water range. The analysis of moisture status becomes more complicated with the different stages growth and root penetration. Some cops send out few widely spaced roots and have relatively sparse root system. With these, soil moisture determinations may give a false impression of the irrigation needs of the crop (FAO, 1973).

Response of Common Bean Cultivars and Lines to Water Stress

Juliana *et. al*. (1993) defines drought as the relative yield of a genotype compared to other genotypes subjected to the same water stress. Susceptibility to drought is frequently measured by reduction in grain yield, but the values are frequently confused with the potential genotype yields. Drought tolerance implies the ability to sustain reasonable yields under moderate water stress, and not the ability to survive over prolonged and severe water stress periods.

Effect of Water Stress on Growth
Stages of the Plant

Maiti (1997) stated that the normal process of seedling development is largely controlled by environmental factors and influences the development of the adult plant. Kramer (1976) as cited by Bawang (1990) stated that the vegetative growth is particularly sensitive to water deficit because growth is closely related to turgor and thrashing of turgidity stops cell divisions.

He also concluded that the water content of plants ranges from 70 to 90% depending on the species, organs, development stages and environment. There are critical stages in plant development when water stress or excess can cause significant decreases in yield. Many plant species do not have the water to use in drought periods and need supplemental water during this period. Thus, defining the appropriate time, amount and method of irrigation for each plant species will increase the efficiency of supplemental water. It is also important to know the root depth, the minimum water requirement at that depth and the water use efficiency of each species to increase irrigation benefits.

Effects of high temperature and heat stress

Zharan (1999) stated that high soil temperatures in tropical and subtropical areas are a major problem for biological nitrogen fixation (BNF) of legume crops. High root temperatures strongly affect bacterial infection and nitrogen fixation in beans. Temperature affects root hair infection, bacteroid differentiation, nodule structure, and the functioning of the legume root nodule.

Wanab (1999) declared that heat shock proteins have been found in rhizobium. The synthesis of heat shock proteins was detected in both heat-tolerant and heat-sensitive bean nodulating rhizobium stress at different temperatures. Heat tolerant rhizobia are likely to be found in environments affected by temperature stress.

General Effects of Water Logging

Del Rosario and Fajardo (1991) stated that water logging and the associated oxygen deficiency elicit several morphological, anatomical and physiological changes in the plant. Typical effects of water logging on plants include reduced growth, clhorosis, senescence, wilting, epinasty, adventitious root and parenchyma formation. Plant height, dry matter yield and leaf area were also significantly decreased. Stomatal resistance increased with a corresponding decreased in transpiration rate and leaf water potential.

They also concluded that oxygen deficiency due to water logging causes a shift in respiratory metabolism from aerobic to anaerobic pathway resulting in low energy yield, accumulation of toxins and rapid depletion of organic compounds.

Suitable Areas for Bush Snap Bean

It is reported that beans grows best on soil that holds water well and have a good air and water filtration. Soil should have a pH of 5.8 to 6.6. Pacher (2002) stated that bush snap beans are warm temperature season vegetables that will not tolerate frost. It requires adequate amount of moisture. Temperature is important for rapid growth. Good pod set, and early maturity.

Suitability of the Area for Production: Planting, Fertilization, Irrigation and Harvest Timing.

PCCARD (2006) stressed that the yield of common bean is best in high elevations and the maturity period is longer than in lower elevations.

In seed production, Ap-apid (1991) found out that the wider the spacing between hills, the heavier were the marketable seed produced per plant. The lightest were produced from plants with 10 centimeters distance due to high competition for light and nutrients among plant per unit area. Similarly, they found out that density of two seeds per hill at a distance of 20 to 30 centimeter between hills yielded the heaviest seeds per plot.

He concluded that irrigation is an essential requirement on the farm when rainfall is not secured. Without the selection of seeds, application of adequate fertilizer insect pest and disease control and the practice of improve cultural management could ensure production of crops with maximum economic returns.

Hampton (1987) stated that a number of factors have been used to estimate the point of which seeds are harvestable. This includes seed consistency, seed shattering, crop color, leaf senescence and moisture content. He further stated that basing harvest timing on seed consistency over a whole crop especially when flowering have been spread over a period from only few days to several weeks is a good indicator. However, estimating shattering loss in a crop is often a poor indicator of harvest timing.

MATERIALS AND METHODS

The experiment was done at Benguet State University (BSU) - Experimental Station in Balili, La Trinidad, Benguet in an open field. The area was properly cleaned. Plots were prepared with a measurement of 1m x 5m and filled with bio- fertilizer. Three bean seeds were planted at a distance of 25cm x 30cm at a depth not exceeding 2.5 centimeters. The study was laid out using 3 x 5 factorial in split- plot design with three replications. Weeding was done to avoid water and nutrient competition on the crop. Irrigation management as treatment was strictly applied to the plant when the true leaves fully appeared (Figure 1). The different levels of water served as Factor A and the three bush snap bean varieties served as Factor B.

Factor A: Levels of water (W)

Code	Treatment
W_1(control)	8 L of water per $5m^2$ will be applied to all control plants every other day (Farmers practice)
W_2	32 L of water per $5m^2$ will be applied to all plants every other day
W_3	20 L of water per $5m^2$ will be applied every other day to all Plants
W_4	4 L of water per $5m^2$ will be applied every other day to all plants.
W_5	1.8 L of water per $5m^2$ will be applied every other day to all Plants

Factor B: Varieties (V)

Code	Variety	Source
V_1	Contender	BSU- NPRCRTC
V_2	Blue Lake	Mr. PAYANGDO
V_3	Bokod	BSU- NPRCRTC

The data gathered were the following:

1. Plant vigor. This was taken using this scales at 30 DAP and DAP. (NPRCRTC, 1997).

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

2. Initial plant height (cm). This was measured from the base of the plant t the ground level to the youngest shoots, using a meter stick or a foot rule from five plant samples in different treatment at 30 days after planting (DAP).

3. Final height (cm). This was measured from the base of the plant at the ground level to the youngest shoots, using a meter stick or a foot rule from five plant samples in different treatment at 60 DAP.

Figure 1. Bush snap bean at 13 DAP (formation of true leaf has fully appeared in the start of applying the different levels of water)

4. Number of days from sowing to emergence. This was recorded by counting the number of days from sowing to emergence and when at least 60% of the seed sown has emerged.

5. Days from emergence to flowering. This was recorded starting from emergence to the day when 60% of plants have flowered.

6. Days from emergence to pod settings. This was taken by counting the number of days starting from flowering to the days when pods are formed at the same time recording the date of pod setting.

7. Days from emergence to first harvest. This was recorded by counting the number of days from emergence to first harvest at the same time recording the date of first harvest.

8. Days from emergence to last harvest. This was taken by counting the number of days emergence to last harvest at the same time recording the date of last harvest.

9. Number of flower cluster per plant. This was taken by counting the flower cluster from the five sample plants.

10. Number of flower per cluster. This was taken by counting the flowers per cluster from the five sample plants.

11. Number of pods per cluster. This was recorded by counting the number of pods per cluster from the five sample plants.

12. Percentage pod set per cluster. This was taken by using this formula:

$$\% \text{ Pod Setting} = \frac{\text{Total Number of Pods per Cluster}}{\text{Total Number of Flower per Cluster}} \times 100$$

13. Length of pod (cm). This was recorded by measuring the five randomly selected pods at harvest maturity.

14. With of pod (cm). This was recorded by measuring the five randomly selected pods at harvest maturity.

15. Root length (cm). This was recorded by measuring the top or primary roots of five sample plants using a meter stick or a foot rule after the last harvest.

16. Number of crown roots. This was recorded by counting the crown roots of five sample plants.

17. Disease and Pest Incidence. This was noted by visual observation and was assessed by rating the degree of disease and insect damage on the crop at 30 DAP and 60 DAP.

a. Bean rust. (as cited by Jose, 2004).

Scale	Description	Remark
1	No infection	High resistant
2	1-25% of the total plants are infected.	Mild resistant

Scale	Description	Remark
3	25-50% of the total plants are infected.	Moderate resistant
4	50-75% of the total plants are infected.	Susceptible
5	75-100% of the total plants are infected.	Very susceptible

b. Pod borer.

Scale	Description	Remark
1	No infection	High resistant
2	1-25% of the total plants are infected.	Mild resistant
3	25-50% of the total plants are infected.	Moderate resistant
4	50-75% of the total plants are infected.	Susceptible
5	75-100% of the total plants are infected.	Very susceptible

18. Weight of marketable fresh pod per plot (kg). This was the pods that are well-formed, smooth and free from damages. The fresh pod of variety in different treatment was weighed after harvest.

19. Weight of non- marketable fresh pods per plot (kg). This was the pods that are malformed, and damage by pest and diseases. This was obtained by weighing the non-marketable fresh pods of variety in different treatment.

20. Total yield per plant (kg). this was recorded by getting the total weight of marketable and non- marketable fresh pods per plot in the different treatment throughout the harvest period.

21. Return on cash expense. This was obtained using this formula:

$$ROCE = \frac{\text{Net Income}}{\text{Total Cash of Production}} \times 100$$

22. Agro- climatic data. The average monthly temperature, relative humidity, sun intensity was obtained from the PAG-ASA from December 2011- February 2012.

23. Soil moisture content. This was obtained by getting 10g of soil in the different treatment. Oven dried and computed using the formula:

$$\text{Moisture Content} = \frac{\text{Fresh Weight} - \text{Oven-dry Weight}}{\text{Oven Dry Weight}} \times 100$$

Data Analysis

All quantitative data was subjected for analysis of variance using Split- Plot Design with three replications. The significance of difference among treatment means was tested using the Duncan's Multiple Range Test (DMRT) at 5% level of significance.

RESULTS AND DISCUSSION

Agro- Climatic Data During the Study Period

Table 1 shows the temperature, relative humidity, rainfall amount and sunshine duration. Temperature range from 22 to 23 ˚C, relative humidity is 85 to 87 %, and sunshine duration in minutes ranged with a total of 7578 to 10554 while the rainfall amount ranges from 3.0 to 20.0 mm.

The agro climatic data were favorable to the production of the three bush snap bean. Snap bean grows best in areas with temperatures between 15 to 21 ºC. Bush bean can tolerate low temperature and can tolerate warm temperature up to 25 ºC (HARRDEC, 2000). In addition, AVRDC (1990) reported that beans requires high light level and is also sensitive to flooding.

Table 1. Agro climatic data during the study period (December 2011 to February 2012)

MONTH	TEMPERATURE (ºC)	RELATIVE HUMIDITY (%)	SUNSHINE DURATION	RAINFALL AMOUNT (mm)
	MEAN		(minutes)	
December	23	87	7578	20
January	22	85	10554	10
February	22	86	8492	3
MEAN	22	86	8875	11

Plant Vigor at 30 DAP

Effect of water level. Results showed that there were significant differences on the plant vigor of bush beans applied with different levels of water at 30 DAP as shown in Table 2.

The application of 8, 20 and 32 L of water produced a highly vigorous plants but comparable with the application of 4 L of water. A moderate vigorous plant was observed with the application 1.8 L of water.

Table 2. Plant vigor of the three bush snap bean varieties as affected by the different levels of water applied

TREATMENT	PLANT VIGOR (30 DAP)
Water level (W)	
8 L (farmer's practice)	5^a
32 Liters	5^a
20 Liters	5^a
4 Liters	4^b
1.8 Liters	4^b
Variety (V)	
Contender	5
Blue Lake	5
Bokod	5
W x V	ns
CV (a) %	9.63
CV (b) %	7.18

Means followed by common letters are not significantly different at 5% level of DMRT.

Legend: 1- poor vigor; 2- less vigor; 3- vigorous; 4- moderately vigorous; 5- highly vigorous

Effect of variety. Results showed that there were no significant differences among varieties. All of the varieties are strong with robust stem and leaves are light to dark green color.

Interaction effect. The interaction between the different levels of water and bush snap bean varieties was observed to be not significant on plant vigor at 30 DAP.

Plant Height at 40 and 60 DAP

Effect of water level. There were significant differences noted on the plant height of the three bush snap beans at 30 and 60 DAP. Taller plants were noted in the bush snap beans varieties applied with 20 L of water with a height of 31.87 cm (Table 3). This could be attributed to enough moisture applied to the plant for growth.

Tisdale and Nelson (1975) stated that moisture stress causes reduction in the cell elongation, hence retarding the growth of the plant.

Effect of variety. The plant height of the three bush snap bean varieties was not significantly different at 40 DAP but at 60 DAP Blue Lake was the tallest plant with a mean height of 30.60 cm. The differences noted could be attributed to the genetic characteristic of the bush bean varieties.

Interaction effect. Statistically, there was no significant interaction effect between the different levels of water application on the plant height of the three bush snap bean varieties.

Days from Sowing to Emergence,
Flowering and Harvesting

Effect of water level. No significant differences were observed on the number of days to emergence until harvesting of the three bush snap bean varieties as affected by

Table 3. Plant height at 40 DAP and 60 DAP of the three bush snap bean varieties as affected by the volume of water application

TREATMENT	PLANT HEIGHT (cm)	
	40 DAP	60 DAP
Water level (W)		
8 L (farmer's practice)	29.76[ab]	30.06[b]
32 Liters	30.39[ab]	30.50[b]
20 Liters	31.80[a]	31.87[a]
4 Liters	29.93[ab]	30.00[b]
1.8 Liters	28.28[b]	29.38[b]
Variety (V)		
Contender	29.99	30.16[b]
Blue Lake	30.65	30.68[a]
Bokod	29.46	30.32[b]
W x V	ns	ns
CV (a) %	4.07	2.16
CV (b) %	5.35	1.35

Means followed by common letters are not significantly different at 5% level of DMRT.

the different levels of water application. Different levels of water were applied after the appearances of true leaves at 13 DAP as shown in Figure 1.

Effect of varieties. Result showed that the three bush snap bean varieties uniformly emerged 7 days after sowing, flowered at 33 days from emergence. Pod setting was recorded at 40 days after emergence (DAE) while the first harvest commenced at 48 DAE and the last harvest was recorded at 62 DAE.

Interaction effect. There were no significant differences observed on the number of days from emergence to flowering, to pod setting and harvesting as affected by the varieties and the different levels of water.

Number of Flower Clusters per Plot
and flowers per cluster

Effect of water levels. As shown in Table 5, there were no significant differences on the number of flower cluster as affected by the application of different levels of water. All of the bush snap bean varieties produced seven to nine flower clusters with five to six flowers per cluster.

Effect of variety. Result showed that a significant difference among the varieties on the number of flower cluster produced. Blue Lake produced the highest number of flower cluster (8.53) while Contender and Blue Lake produced a comparable numbers of flower cluster. On the number of flower per cluster, no significant differences were observed. The numbers of flower cluster is an important factor contributing to yield of the plants. Theoretically, the more the flower cluster, the greater the yield (Singha, 1973).

Interaction effect. There was no significant interaction effect between the different levels of water application on the bush snap bean varieties on the number of flower cluster and flower per cluster.

Numbers of Pods per Cluster and
Percent Pod Set per Clusters

Effect of water levels. Statistically, there was no significant effect of the different levels of water application on the production of pod per cluster and percent pod set per cluster of the different varieties of bush snap beans. The number of pod per cluster produced had a means of 4.44 to 5.77 pods and 79.85 to 92.77 percent pod set per cluster.

For all crops grown for fruits and seed, Chapman and Carter (1976) stated that moisture stress before, during and immediately after flowering seems to have the greatest effect on

Table 4. Number of flower clusters and flowers per cluster of bush snap bean as affected by different levels of water applied

TREATMENT	NUMBER	
	FLOWER CLUSTER	FLOWER PER CLUSTER
LEVELS OF WATER (W)		
8 L of water (farmer's practice)	8	6
32 L of water	8	6
20 L of water	9	6
4 L of water	8	5
1.8 L of water	7	5
VARIETY (V)		
Contender	8[b]	5
Blue lake	9[a]	6
Bokod	8[b]	5
W x V	ns	ns
CV (a) %	14.15	21.69
CV (b) %	12.15	19.77

Means followed by common letters are not significantly different at 5% level of DMRT.

reducing yield. In addition, high soil moisture levels during seed formation, pod and seed coloring will result in white-mold damage, delayed maturity and quality problems.

Effect of varieties. The different varieties used significantly affected the number of pods per cluster produced by the bush snap beans (Table 5). Blue lake were produced the highest number of fresh pods of 5.66. Comparable percentage of pod set per cluster was recorded in all the varieties. Salehi et al.,(2008) stated that excessive abortion of flowers, young pods and seeds occur in dry bean because of water stress during pre-flowering (10 to 12 days before anthesis) and reproductive periods.

Interaction effect. No significant interactions were noted in terms of pod per cluster and percent pod set per cluster on the three varieties of bush snap bean as affected by different levels of water applied.

Pod Length and Width

Effect of water levels. No significant differences on the effect of the different volume of water application on the pod length while a significant difference was observed on the width of the different varieties of bush snap beans as shown in Table 6. Pod length ranges from 14.17 cm to 15.22 cm while on the pod width the application of 20 L of water produced wide pods (0.78 cm).

Table 5. Number of pods per cluster and percentage pods set per cluster as affected by different levels of water applied

TREATMENT	NUMBER OF POD PER CLUSTER	PERCENTAGE OF POD SET PER CLUSTER
LEVELS OF WATER (W)		
8 L of water (farmer's practice)	5	86.50
32 L of water	4	79.85
20 L of water	6	92.77
4 L of water	4	81.62
1.8 L of water	5	91.56
VARIETY (V)		
Contender	4^{b}	83.89
Blue lake	6^{a}	91.29
Bokod	4^{b}	83.89
W x V	ns	ns
CV (a) %	19.55	14.34
CV (b) %	18.46	14.93

Means of the same letters are not significantly different at 5% level of DMRT.

Effect of varieties. There was a significant differences noted on the different varieties of bush snap beans in terms of length and pod width. Blue lake significantly produced the longest and widest pod of 14.96 cm and 0.78 cm, respectively. The narrowest and shortest pods were observed in Bokod and Contender.

Interaction effect. A significant interaction effect was recorded in terms of pod length as shown in Table 6 and Figure 2. The application of 32 L of water in the Blue Lake recorded a longest pod of 15.95 cm in terms of pod width, no significant interaction effect was noted.

Kattan and Fleming (1996) reported that irrigation during the period of planting to blooming had effect on the yield of snap beans. Moisture stress during the pod

Table 6. Pod length and width of bush snap bean varieties as affected by different levels of water applied

TREATMENT	POD (cm)	
	LENGTH	WIDTH
LEVELS OF WATER (W)		
8 L of water (farmer's practice)	14.48	0.65[b]
32 L of water	15.05	0.69[b]
20 L of water	15.22	0.78[a]
4 L of water	14.57	0.66[b]
1.8 L of water	14.17	0.65[b]
VARIETY (V)		
Contender	14.61[b]	0.67[b]
Blue lake	14.96[a]	0.71[a]
Bokod	14.52[b]	0.67[b]
W x V	*	ns
CV (a) %	6.80	9.15
CV (b) %	2.69	6.00

Means followed by common letters are not significantly different at 5% level of DMRT.

development and harvest was most detrimental to yield, size, and quality of pods. They concluded from their study that pod set was markedly lowered at soil moisture levels exceeding field capacity or at soil moisture levels approaching the wilting coefficient.

Number of Roots

Effect of water levels. Statistically, result showed that there were no significant effects of the different levels of water applied on the number of crown roots (Table 7).

Numerically, the application of 20 L of water gave the highest number of crown roots with 8.88. The least number of crown roots was observed on plants applied with 1.8 L of water.

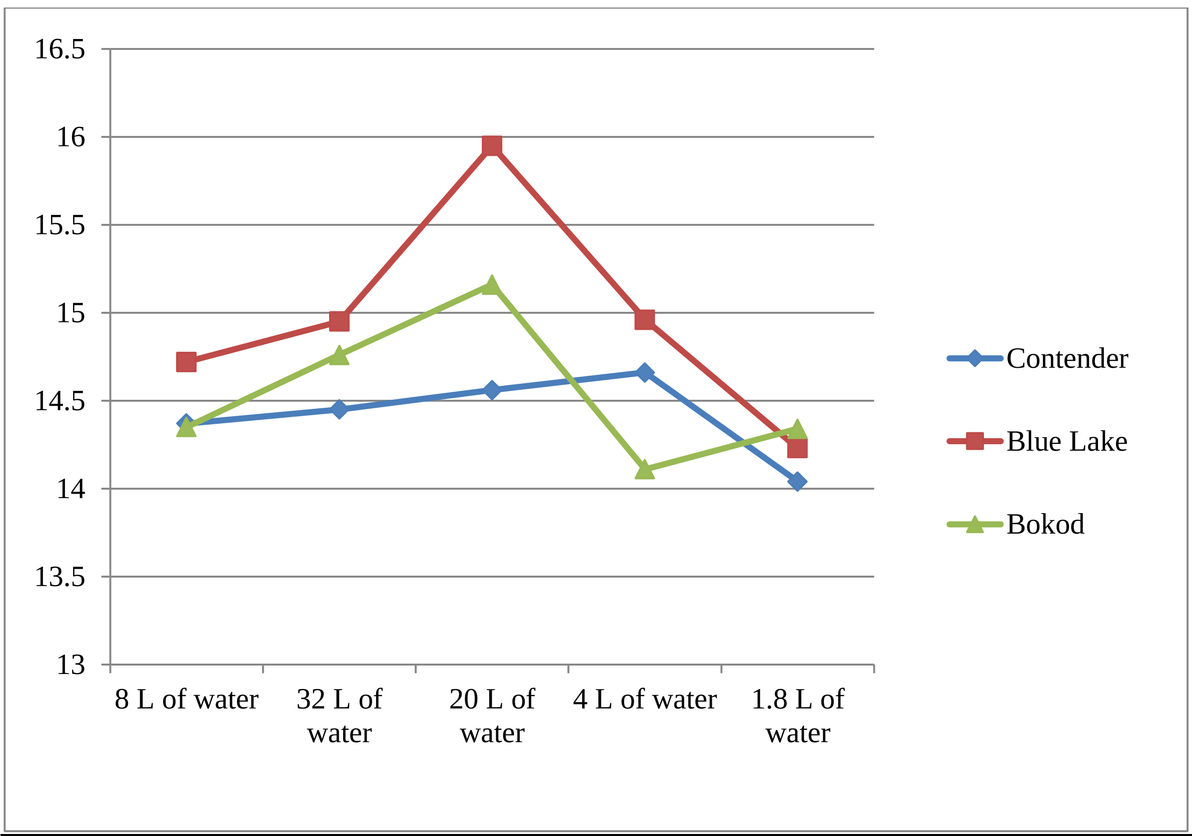


Figure 2. Interaction effect of the different levels of water and the bush snap bean varieties on the length of pods.

Effect of varieties. As shown in Table 7, Blue lake significantly displayed the highest number of crown roots of 8.24. The differences noted could be genetic in nature.

Interaction effect. No significant interaction was noted in terms of the number of crown roots of the three varieties of bush snap bean as affected by the different levels of water application.

Tap Root Lengt

Effect of water level. Result showed that there were no significant differences on the different levels of water applied on the root length as shown in Table 7. The root length ranges from 33.73 cm to 45.80 cm

Effect of varieties. Significant differences were observed on the root length as shown in Table 9 and Figure 4. Blue lake and Bokod was noted to produce the longest roots of 42.66 and 41.37 cm respectively, while Contender produced the shortest root length of 37.99 cm. In area where there is a deficit of water the root of the plant should grow longer to absorb water from the lower depths while, excess water can also reduced root development and development of adventitious roots (AVRDC, 1990).

Interaction effect. There was significant interaction effect noted in terms of root length on the three varieties of bush snap bean as affected by the different levels of water applied (Figure 3). The application of 20 liters of water or the farmer's practices on Blue Lake significantly produced the longest root length of 50.37 cm.

Table 7. Number of roots and tap root length of bush snap bean as applied with different levels of water

TREATMENT	NUMBER OF ROOTS	TAP ROOT LENGTH (cm)
LEVELS OF WATER (W)		
8 L of water (farmer's practice)	8	45.80
32 L of water	8	34.34
20 L of water	9	45.79
4 L of water	7.77	43.71
1.8 L of water	7.44	33.73
VARIETY (V)		
Contender	8.00[b]	37.99[b]
Blue lake	8.26[a]	42.66[a]
Bokod	7.66[b]	41.37[a]
W x V	ns	*
CV (a) %	13.67	33.02
CV (b) %	6.74	12.03

Means followed by common letters are not significantly different at 5% level of DMRT.

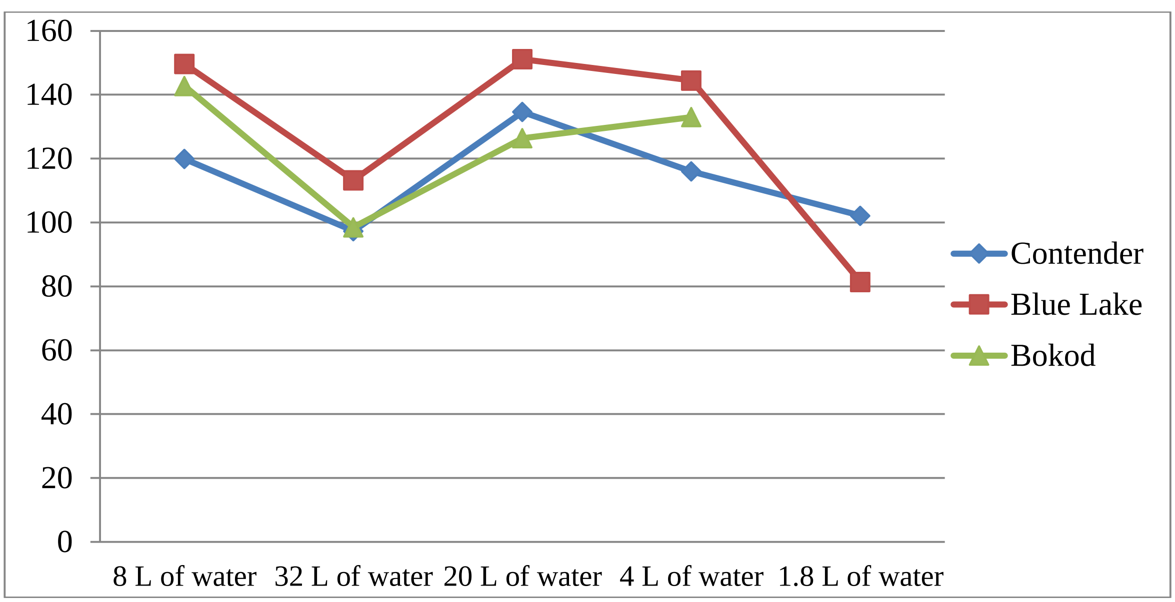


Figure 3. Interaction effect of the different levels of water and the bush snap bean varieties on the length of tap roots.

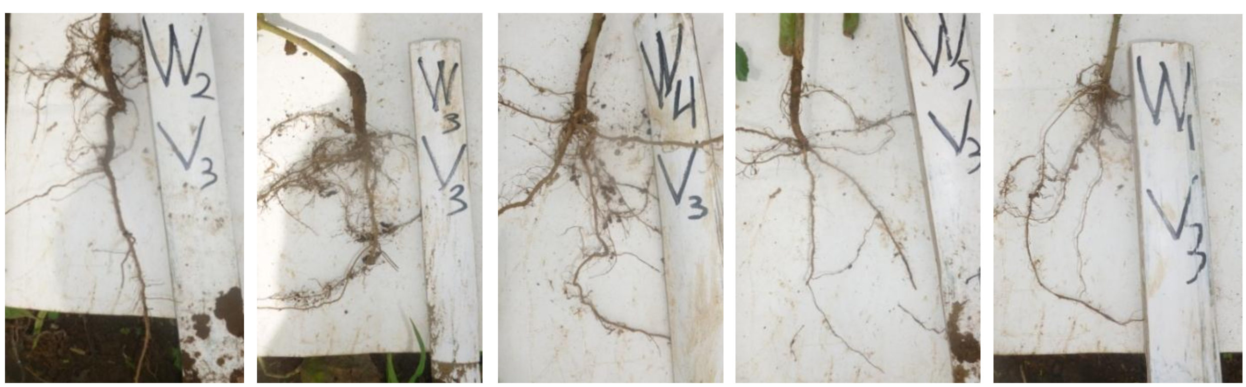
CONTENDER

W_1- 8 L of water W_2- 32 L of water W_3- L of water W_4- 4 L of wate W_5- 1.8 L of water

BLUE LAKE

W_1- 8 L of water W_2- 32 L of water W_3- L of water W_4- 4 L of water W_5- 1.8 L of water

BOKOD



W_1- 8 L of wate W_2- 32 L of water W_3- L of water W_4- 4 L of water W_5- 1.8 L of water

Figure 4. Roots of the different bush snap bean varieties as affected with the different levels of water

Reaction to Bean Rust and Pod Borer

The three varieties applied with different levels of water showed mild resistance to bean rust which means 1 to 25% of the total plant is infected. Resistance to bean rust plays an important role in bush snap bean production because infection could affect the photosynthetic activity of the plant. While the reaction on pod borer as monitored at 60 DAP showed that the three varieties of the bush snap bean were all moderately resistant to pod borer regardless of the different levels of water applied.

Weight of Marketable Fresh Pods

Effect of water levels. Highly significant differences were obtained on the weight of marketable fresh pods as affected by the different levels of water applied on the three bush snap bean varieties.

Numerically, application of 20 L of water yield higher pods (8.20 kg) per 5m^2 while the lowest marketable pods were observed in plants applied with 1.8 L of water. Lack and excess of soil moisture content can affect the biomass yield of the crops.

Effect of variety. A significant difference among the three varieties was observed in terms of marketable weight of fresh pods as shown in Table 8 and Figure 5. Blue Lake and Bokod produced heavier marketable pods of 5.66 and 5.52 kg/5 m^2, respectively while contender produced the least.

Interaction effect. No significant interaction effect was recorded in terms of the marketable weight of fresh pods of the three varieties as affected by different levels of water applied.

Non- Marketable Weight of Fresh Pods

Effect of water levels. There were significant differences noted on the different levels of water applied in terms of non- marketable fresh pods. The application of 1.8 liters of water produced the highest non- marketable fresh pods while plants applied with 20 liters of water had the lowest non- marketable fresh pods.

Effect of varieties. The production of non- marketable fresh pods was not significant among the varieties of bush snap bean as shown in Table 8. Non- marketable pod weight ranges from 1.49 to 1.76 kg.

Interaction effect. No significant interaction effect was noted in terms of the production of non- marketable weight of fresh pods on the three varieties of bush snap bean as affected by the different levels of water applied.

Total Yield

Effect of water levels. Table 10 showed that the application of 20 L of water produced the highest total yield per $5m^2$ of 7.87 kg, comparable with the application of four liters (7.12 kg) and 1.8 liters of water (6.96 $kg/5m^2$). The lowest total yield was noted on plants applied with 32 L of water with 6.56 $kg/5m^2$ of fresh pods produced. It was observed that the plant applied with 20 liters of water had the highest marketable yield and produced the lowest non- marketable yield.

Water stress reduces the rate of photosynthesis and uptake of nutrient. Water stress also affects crop phenology, leaf area development, flowering, pod setting and finally results in low yield (Phogat *et al.,* 1984).

Table 8. Weight of marketable pods, non-marketable pods and total yield per plot of three bush snap bean as applied with the different levels of water

TREATMENT	WEIGHT OF PODS (kg/5m^2)		TOTAL YIELD (kg/5m^2)
	MARKETABLE	NON-MARKETABLE	
LEVELS OF WATER (W)			
8 L of water (farmer's practice)	5.48^b	1.64^{ab}	7.12^c
32 L of water	5.19^{bc}	1.49^{ab}	6.56^b
20 L of water	7.15^a	0.93^b	7.87^a
4 L of water	4.97^{bc}	1.78^{ab}	6.85^{ab}
1.8 L of water	4.40^c	2.48^a	6.96^{ab}
VARIETY (V)			
Contender	5.14^b	1.76	6.82
Blue lake	5.66^a	1.49	7.10
Bokod	5.52^a	1.74	7.29
W x V	ns	ns	ns
CV (a) %	10.98	38.90	9.94
CV (b) %	8.73	28.42	8.44

Means followed by common letters are not significantly different at 5% level of DMRT.

Effect of variety. The production of total yield per plot was not significant among the varieties of bush snap beans as shown in Table 8. Total yield ranges from 6.82 to 7.29 kg/5m^2.

Interaction effect. No significant interaction was noted in terms of total yield per plot on the three varieties of bush snap beans as affected by the different levels of water applied as shown in Table 8.

CONTENDER

W_1- 8 l of water W_2- 32 L of water W_3- 20 L of water W_4- 4 L of water W_5- 1.8 L of water

BLUE LAKE

W_1- 8 L of water W_2- 32 L of water W_3- L of water W_4- 4 L of water W_5- 1.8 L of water

BOKOD

W_1- 8 L of water W_2- 32 L of water W_3- L of water W_4- 4 L of water W_5- 1.8 L of water

Figure 5. Pods of the three bush snap bean varieties as affected by the different levels of water applied

Soil Moisture Content
at 25 DAP and 56 DAP

Effect of water levels. Results showed a significant effect of the different levels of water applied on the soil moisture content as shown in Table 11. The application of 1.8 L of water has the highest in terms of soil moisture content at 25 DAP and 60 DAP of 21.33 and 22.44 %, respectively while the lowest was recorded in plants applied with 32 L of water of 10.33 and 11.00 percent. Chapman and Carter (1976) stated that when water exceeds the soil's water holding capacity or where impermeable subsoil slows water infiltration, water logging, flooding or ponding may occur. Wet soils slow down or stop gas exchange between the soil and atmosphere, causing an oxygen deficiency. Lack of oxygen reduces root respiration and growth.

Effect of varieties. Statistically, there were no significant effects obtained on the three varieties of bush snap bean. The mean soil moisture content ranges from 16.60 to 16.87 %.

Interaction effect. No significant effect was obtained in terms of soil moisture on the three bush snap bean varieties as affected by the different levels of water applied.

Return on Cash Expense

Effect of water levels. Table 10 shows the return on cash expense (ROCE) per $5m^2$ of the three bush snap bean varieties applied with different levels of water. The cost production includes land preparation, bio- fertilizers, seeds and labor. Application of 20 L of water produced the highest gross income of P536.50, net income of P292.18 and ROCE of 119.58 %, while plants applied with 1.8 liters of water has a low net income of P85.35 and 34.93% ROCE.

Effect of variety. All of the varieties obtained a positive ROCE (Table 10). The highest net income of 901.65 and 73.81% ROCE were produced by Blue Lake while the lowest income and ROCE was obtained from Contender with a net income of P706.15 and 57.81% ROCE.

Interaction effect. The cost and return on cash expense between the three bush snap bean varieties and levels of water applied is shown in Table 10. The application of 20 L of water in Blue Lake realized the highest yield, gross and net income and recorded the highest ROCE of 108.12 to 133.70 %. The lowest ROCE was obtained in plants applied with 1.8 liters of water (27.39 – 48.57%).

Table 9. Soil moisture content at 25 and 56 DAP of the three bush snap bean varieties as applied with the different levels of water

TREATMENT	SOIL MOISTURE CONTENT (%)	
	25 DAP	56 DAP
LEVELS OF WATER (W)		
8 L of water (farmer's practice)	19.11[b]	19.89[b]
32 L of water	10.33[d]	11.00[d]
20 L of water	13.67[c]	14.56[c]
4 L of water	19.00[b]	20.22[b]
1.8 L of water	21.33[a]	22.44[a]
VARIETY (V)		
Contender	16.60	17.20
Blue lake	16.60	17.93
Bokod	16.87	17.73
W x V	ns	ns
CV (a) %	6.99	23.15
CV (b) %	9.36	11.07

Means followed by common letters are not significantly different at 5% level of DMRT.

Table 10. Return on cash expense of the three bush snap bean varieties as affected by different levels of water applied

TREATMENT	YIELD (kg/5m^2)	GROSS INCOME (PhP)	COST OF PRODUCTON (PhP)	NET INCOME (PhP)	ROCE (%)
8 L of water					
Contender	16.32	408.00	244.32	163.68	66.99
Blue Lake	16.73	418.25	244.32	173.93	71.19
Bokod	16.28	407.00	244.32	162.68	66.58
Mean	16.44	411.08	244.32	166.76	68.25
32 L of water					
Contender	13.91	347.75	244.32	103.43	42.33
Blue Lake	16.08	402.00	244.32	157.68	64.53
Bokod	16.76	419.00	244.32	174.68	71.49
Mean	15.58	389.58	244.32	145.26	59.45
20 L of water					
Contender	20.34	508.50	244.32	264.18	108.12
Blue Lake	22.84	571.00	244.32	326.68	133.70
Bokod	21.2	530.00	244.32	285.68	116.92
Mean	21.46	536.50	244.32	292.18	119.58
4 L of water					
Contender	14.09	352.25	244.32	107.93	44.17
Blue Lake	14.76	369.00	244.32	124.68	51.03
Bokod	15.92	398.00	244.32	153.68	62.90
Mean	14.92	373.08	244.32	128.76	52.70
1.8 L of water					
Contender	12.45	311.25	244.32	66.93	27.39
Blue Lake	14.52	363.00	244.32	118.68	48.57
Bokod	12.59	314.75	244.32	70.43	28.82
Mean	13.19	329.67	244.32	85.35	34.93

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

Growth and yield of bush snap bean varieties irrigated with different levels of water was conducted in La Trinidad, Benguet in an open field condition from December 2011 to February 2012. The objectives of the study were to determine growth and yield of the different bush bean varieties, determine the growth and yield of bush snap bean varieties applied with different water levels, and determine the interaction effect of the different bush bean varieties under different levels of water.

Among the water levels applied, the application of 20 L of water had the tallest plant height at 40 DAP and 60 DAP, longest and widest pod length, produced more roots, produced more flowers per cluster and have the highest total yield, highest gross and net income and ROCE but comparable to the application of 32 L of water on plant vigor that produced a highly vigorous plants. The application of 1.8 liters of water had the highest water holding capacity.

Blue lake had the tallest plant height at 40 and 60 DAP, produced more flower clusters, more pods per cluster and produced the highest total of marketable fresh pods. Blue Lake and Contender produced the lowest weight of non- marketable fresh pods.

On the interaction effect, the application of 20 L of water on Blue Lake produced the longest length of pods and tap root length while application of 1.8 L of water on Contender produced the shortest length of pods. The different levels of water significantly affected the number of roots and length of the roots of the different bush snap bean varieties.

Conclusions

Based on the findings, Blue Lake variety is the best performing as it produced the tallest plants, more flowers, clusters and pods, longest and widest pods, highest number of roots and longest tap root length, highest marketable pods, gross income, net income and ROCE.

Irrigation of 20 liters of water produced the tallest plants, widest pods, longest pods and tap root length, highest marketable, total yield and highest gross income, net income and ROCE.

The interaction of 20 liters of water and Blue Lake produced the longest pods and longest roots but comparable to the application of 1.8 liters of water on Contender which had the shortest pods while the application of 1.8 liters of water produced the shortest tap roots.

Recommendations

From the results of the study, it is recommended that for bush bean production under La Trinidad condition, the best level for irrigation is 20 liters of water and the best bush bean variety is Blue Lake.

LITERATURE CITED

AP-APID, N.W. 1991. Optimum Spacing Requirement for Seed Production of Pole Snap Beans. BS Thesis(Unpub.) Benguet State University, La Trinidad, Benguet. Pp. 17-18.

ASIAN VEGETABLE RESEARCH DEVELOPMENT CENTER (AVRDC). 1990. Vegetable Production Training Manual. Taiwan: AVRDC. Pp. 128-130.

BANTOG, N. 1983. On- Farm Elevation of Promising Varieties and Farmers Production Practices of Pole Snap Beans in Different Elevations. Unpublished MS dissertation. Benguet State University, La Trinidad, Benguet. Pp. 12-13.

BAWANG, F.T. 1990. The Effect of Moisture Stress on the Growth and Yield of White Potato. La Trinidad: Deth News Philippines. P. 259.

CHAPMAN, S.R. and L.P. CARTER. 1976. Crop Production: Principles and Practices. San Francisco: Freeman and Compony. Pp. 128-130.

DEL ROSARIO, D.A. and F.F. FAJARDO. 1991. The Philippine Agriculturist. Water Logging Resistance in Crops. 74(1):51.

FOOD AND AGRICULTURE ORGANIZATION (FAO), 1973. Irrigation Drainage and Salinity. Water, Plant Growth and Crop Irrigation. London Sydney Auckland. Hutchinson and Co(publishers) LTD. Pp. 211-213.

HALFACRE, D. and R. BARDEN. 1980. Horticulture. New York, USA: Mc Millen Publishing Company. Pp. 22-23.

HAMPTON,J.G.1987. On Farm Evaluation of Potential Varieties of Pole Snap Beans. BS Thesis(Unpub.) Benguet State University, La Trinidad, Benguet. P. 7.

HIGHLAND AGRICULTURE AND RESOURCES RESEARCH AND DEVELOPMENT CONSORTIUM (HARRDEC). 2000. Snap bean Farmers Guide. Primer. Published by HARRDEC- PCARRD. Pp. 57-50.

JULIANA, C.M; V.M. CIRINO; N.F. JUNIOR; R.T. DE FARIA and D. DESTRO. 1993. Crop Breeding and Applied Biotechnology, v.1, n. 4. Pp. 363-372.2001.

KATTAN, A.A., and J.W. FLEMING, 1996. Effect of irrigation at specific stages of development on yield, growth, and composition of snap beans. Proceeding of the American Society for Horticultural Science. 68:329-342.

LIU, Y; L. 2010. Biological Nitrogen Fixation of Legumes. Models of Biological Nitrogen Fixation of Legumes. retrieved on Augost 06, 2011 at http//www.agronomy-journal.org/index.php?option=com_articl.

LOAKAN, M.S. 2003. Evaluation of Alno Derived Selections of Snap Beans Obtained from Different Sources in Benguet. Pp. 1-11.

MAITI, R.K. 1997. Bean Sciense. Pueblo, Mexico: Science Publishers Inc. Pp. 1-2, 15-16, 23.

PACHER, S. 2002. Kitchen Garden about Snap Beans. Retrieve on august 06, 2011 From http:www. Mothereath news. Com.

PHILIPPINE COUNCIL FOR AGRICULTURE, FORESTRY AND NATURAL RESOURCES RESEARCH AND DEVELOPMENT (PCCARD). 2006. Organic Fertilizer and Utilization. Los Baños, Laguna: PCCARD. P. 132.

PHOGAT, B.S., D.P. SINGH, and P. SINGH. 1984. Response of Cowpea and Mungbean. To Potter N.N. and J.H. Hotckiss. 1997. Food Science. CBS Publisher, New Delhi, India. P. 403.

PURSEGLOVE, J.W. 1978. Tropical Crops Dicotiledon. University of the West Indies, St. agustin Trinidad. P. 297.

SALEHI, M., A. HAGHNAZARI and F. SHEKARI, 2008. The Study of Morpho-physiological Traits of Lentil (*Lens culinaris* Medik) Relation with Grain Yield under Normal and Drought Conditions. Retrieve on February 03, 2012 at http://www. Google. Com.ph/#hl=en&biw= 1366&bih= 543&q=salehi %2C+m.+a.+haghnazari+and+ f+shekari+2006aq=f&aqi=&aql=&fp= ba94db5dd3c30688.

SINGHA, S.K. 1973. Yield of Grain Legumes; Problems and Prospects. India: Indian Journal of Genetics.P.5.

TISDALE, S.C and W.L. NELSON. 1975. Soil Fertility and Fertilizers. New York: Mac Millan Publishing Compony Inc. Pp. 29-30.

WANAB, A.P. 1999. Snap beans and garden pea production. Office of the Director of Extension, Benguet State University, La Trinidad, Benguet. Pp. 1-7.

WHITE, J.K. 1994. Response of Common Bean Cultivars and Line to Water Stress. Retrieved on June 30, 2011 from http://ehow.com/list 7581975 effets-water=bean-plants. Html.

ZHARAN. H.H. 1999. Salt Tolerance of Rhizobium Species in Broth Culture. Z. Microbiol. Pp. 681-685.