

EFFECTS OF WATER STRESS AT DIFFERENT GROWTH STAGES ON THE POD FORMATION OF DIFFERENT VARIETIES OF PHASEOLUS BEAN FOR ECONOMIC DEVELOPMENT

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Abstract

The study was carried out at College of Education Akwanga, Nasarawa State, Nigeria, between January to April 2023 to investigate the effects of water stress at different growth stages on the pod formation of different varieties of *Phaseolus vulgaris* and *Phaseolus coccineus* (Runner, Trailing or Emergo). Significant differences ($P=0.05$) were observed on number of pods per plant and number of seeds per plant. *Phaseolus vulgaris* had more number of pods than *Phaseolus coccineus* with a mean of 8.3 and 4.7 respectively. Least number of pods occurred when *Phaseolus vulgaris* was stressed at flowering and pod formation stages. With *Phaseolus coccineus*, the least number of pods occurred when stressed at flowering stage. Longer number of days to first flower appearance and fruits sets occurred in *Phaseolus coccineus* than with *Phaseolus vulgaris* with a mean of 112.5 days and 51.2 days respectively. More leaves and branches also occurred in *Phaseolus coccineus* than *Phaseolus vulgaris* due to its morphological traits.

Key Words: **Water stress, Pod formation.**

Introduction

One of the political ideologies of the Nigeria state is the achievement of food security. Food security has the capacity to improve nutrition and promote sustainable food production. Food security ensures that a nation is able to produce sufficient food crops to meet the nutritional needs of its citizens without seeking for aids from the international communities. Political ideology is a set of ethical ideas, principles, doctrines, myths or symbols of social movement, etc that explains how society should work and offers some forms of guide for social order. For example, Nigeria is a member state of the United Nations, which in 2016 had among other sustainable goals to achieve food security for stable continents (Valenzuela, Grimsley & Perry, 2023).

National economy on the other hand is about free market economy, where prices and distribution of goods and services are determined by supply and demand with little intervention by the government (Forsyth & Schofield, 2023). Therefore, national economic ideas in Nigeria is about production, distribution, trade, consumption of goods and services by different agents within the nation. It is all about macroeconomics, efficiency, equity, economic freedom and price stability; To achieve these goals, food production must become the focal point of the nation for national economic development, hence the aim of this paper.

Phaseolus vulgaris L. also known as French bean, kidney bean or salad bean belongs to the family Fabaceae and sub-family (Papilionoidae). They are native of America, now cultivated

in both temperate and tropical countries (Pandey, 1980). They are grown for their immature edible pods. The ripe dry seeds are rarely used as much as the immature pods. For example, in Europe, the United States and other temperate countries, they are grown mainly for the green immature pods which are eaten as vegetables. They are also canned and frozen.

The whole dried beans are cooked with tomato sauce and canned and are usually known as baked beans. The straw is used as forage (Byrne, 2023). *Phaseolus vulgaris* has a biological value of 62-68% and a protein content of 6.1% (Milner, 1975, Wikipedia n.d.). The beans is also a source of vitamin B and C which help to promote a healthy nervous system, assist the proper functioning of the digestive and maintain the blood in good condition (Kochhar, 1981, Sair, Adak, Eker & Toker, 2018)

Phaseolus beans is important agriculturally too. It is inter-planted with maize and as a legume, release nitrogen into the soil, which adds to the soil fertility and the vegetative growth of the maize (Onwueme & Sinha, 1991). The bean plants are low, erect, or twining annuals with white or coloured flowers, trifoliate leaves and slender pods (Pandey, 1980). Phaseolus beans have healing effect, it is used as pot-herb in some part of the tropics (Sair, Adak, Eker & Toker, 2018). The crop has varieties which include butter bean *CP. lunatus*, lima bean (*P. limensis*), Scarlet runner bean (*P. coccineus*), Snap bean (*P. vulgaris*), dry and horticultural beans (*P. vulgaris* and so on (Internet, 2025).

Morphology of Phaseolus Bean

Different varieties of Phaseolus beans are cultivated presently. These varieties of Phaseolus beans differ in their growth habit, flower, colour, size, shape and colour of pods and seeds. There are both self-supporting dwarfs and bush cultivars (20-60cm tall and trailing vine or pole types 2-3 cm tall). Bush beans are determinate in their growth habit while the pole types continuously bear races in the leaf axils, while the stems continue to elongate. The stem is slender, herbaceous and angled. The leaves are alternate, trifoliate some-what hairy, having a well-marked pulvinus at the base (Kochhar, 1981). The leaflets are ovate and entire with minute stipels. The flowers are arranged on axillaries racemes, bearing relatively few flowers. The flower structure is typical of the sub-family Papilionioideae. The keel spirally twisted a feature common to all the species of the genus. The pods are yellow or green with or without anthocyanin blotches (Sair, Adak, Eker & Toker, 2018). They are slender (8-10 by 1- 1.5cm) straight or slightly curved with prominent beaks usually glabrous and contain four to six seeds (0.7-1.6cm long). They may be kidney in shape, oblong or globular with usually a white hilum (Kochhar, 1981). They are self-pollinated.

Planting Periods

Dwarf varieties of the beans give good results if planted in the late rains (Kivu, Asanica, Vinatoru, & Barcanu, 2021). The planting could be carried on to the dry season if there is a source of water for irrigation. The trailing varieties give the best result from planting made at the early part of the rainy season (Greensill, 1968; Jana, Mohanta, Chatterjee, Arvind & Behera, 2023). A study carried out in Germany on dwarf French bean on the effect of dry soil conditions imposed at different growth stages showed that plants which suffered drought in the early stages of growth, gave low yields even when adequate water was given later, and this suggested

that some irreversible damage was caused by drought before flowering occurred. Drought conditions during pod-setting also reduced yields (Cambridge, 1968; Manjeru, Madanzi & Makeredza, (2007). In a further pod experiment Cambridge, (1968) found that irrigation at the start of flowering and at pod set increased yields, but that at full flowering, irrigation reduced the crop yield.

Kriegbaum (1955) BoroA_ic, Romic, and Dolanjsk (2000) reported that irrigation applied during the period from germination until just before flowering on dwarf French bean had no effect on yield but when water was given 10 days before, and again 10 days after the end of flowering, it resulted in the highest yield. There was also increase in the number of seeds per pod. Stansell & Smittie (1980) conducted a study on the effects of irrigation regimes on yield and water use of snap beans (*Phaseolus vulgaris* L.). The stages included: sowing, flowering and pod development. Plentiful supply of water before flowering increased vegetative growth but not the yield of the beans. Irrigation given during flowering and pod development resulted in the highest yields and the largest pods. For high quality beans, irrigation during pod development was essential (Cambridge, 1968). A report from Canada on the effect of water stress showed that irrigation was particularly beneficial at the start of flowering until harvest time, but snap beans also responded to irrigation during pre-flowering period (Mackey and Eaves, 1962; Rai, Sharma, & Heitholt, 2020). However, little work appears to have been carried out on the response of runner beans (*P. coccineus*) to soil moisture conditions at different growth stages.

Statement Of The Problem

There is increased production of vegetables during dry season because there is abundance of sunshine, reduced disease incidence, but water is always very limited at this time. Consequently, some farmers are unable to irrigate regularly.

Objective

The purpose of this study was to investigate the possible effects of withholding water from the *Phaseolus* crop at some critical stages of the growth, and use such information to help the farmer in the planting their irrigation activities.

Methodology

The experiment consisted of two species of *Phaseolus* beans (*Phaseolus vulgaris* L. and *Phaseolus coccineus* L.) Soil (sandy loam) was collected from the botanical garden of College of Education Akwanga. The soil was mixed with cow dung, in the ratio of two parts of soil to one part of cow dung. The seeds of the *Phaseolus* bean varieties were obtained from “Farin Gada” vegetable market, Jos, Plateau state. The trial was carried out at the college of Education Akwanga. Between the months of January and April 2023. The trial consisted of eight treatment combinations of *Phaseolus* species and four stress conditions; that is stress at seedling stage, vegetative stage, flowering stage and pod formation stage.

Each treatment was replicated five times. A completely randomized design with five replications was used. The *Phaseolus* bean varieties used were runner bean (Emergo) and snap or bush or green pod. A viability test was conducted to establish the germination status of the

seeds. The seeds were sown on the 26th January, 2023. The water stress treatments consisted of withdrawal of water for one week that is at: seedling stage, vegetative stage, flowering stage, and pod formation stage. The imposition of the various stress treatment did not commence until four weeks after planting when the plants had attained the 6-7 leaf stage.

Observation made included: Number of days to seed germinate, number of leaves before water stress, number of days to first fruit set, number of pods per plant, and one hundred-seed weight. The pods were picked by hand as they matured, air dried, shelled and the total grain yield was then obtained after all pods had been harvested. The yield from each pod was kept separately. Each pot had two plants, therefore, yield per plant was obtained by dividing the pod yield by two.

Results

Number of Days to Seed Germination

Table 1: Effect of Variety on Mean Number of Days to Seed Germination

Varieties	Mean
<i>Phaseolus vulgaris</i>	5.2
<i>Phaseolus coccineus</i>	4.6

Table 1 shows the mean number of days to seed germination. There was a significant difference between the varieties with respect to mean number of days to seed germination. *Phaseolus vulgaris* took longer to germinate 5.2 days compared to 4.6 days for *Phaseolus coccineus*.

Leaf Number

Table 2: Effect of Variety and Sampling Dates on Mean Number of Leaves per Plant

Varieties	Weeks After Planning			
	5	7	8	9
<i>Phaseolus vulgaris</i>	7.1	3.7	3.7	2.2
<i>Phaseolus coccineus</i>	3.3	7.0	9.0	9.1
LSD _{0.05}	2.3	1.4	2.6	2.3

Table 2 shows that *Phaseolus vulgaris* had more leaves at 5 weeks after planting than *Phaseolus coccineus* but subsequently the reverse was the case at all other sampling dates and the differences were significant at ($p=0.05$).

Table 3: Effect of Stress and Sampling Dates on Mean Number of Leaves per Plant

Treatment	Weeks After Planning			
	5	7	8	9
Seeding Stage	11.2	5.7	7.4	6.1
Vegetative Stage	10.2	3.0	7.2	4.2
Flowering Stage	9.1	6.8	3.3	6.7

Pod Formation Stage	10.1	5.8	8.1	5.0
LSD _{0.05}	1.1	2.3	2.31	9.1

Table 3 shows the mean number of leaves per plant for two types of *Phaseolus* beans studied. *Phaseolus coccineus* had significantly more leaves per plant than *Phaseolus vulgaris* and the difference was significant at (P=0.05).

Number Of Leaves Before Applying Water Stress

Table 4: Effect of Variety on Mean Number of Leaves per Plant before Applying Water Stress

Varieties	Mean
<i>Phaseolus vulgaris</i>	7.1
<i>Phaseolus coccineus</i>	13.2

Table 4 shows the mean number of leaves per plant for two types of the *Phaseolus* beans studied. *Phaseolus coccineus* had significantly more leaves per plant than the *Phaseolus vulgaris* and the difference was significant at (P=0.05).

Number Of Days To First Flower Bud Appearance

Table 5: Effect of Variety and Stress on Mean Number of Days to First Flower Bud Appearance

Varieties	Stress Period				LSD 0.05
	Seeding Stage	Vegetative Stage	Flowering	Pod Formation	
<i>Phaseolus vulgaris</i>	28.6	28.4	33.8	26.9	29.4
<i>Phaseolus coccineus</i>	50.6	49.8	54.2	51.2	14.5
Mean	39.6	39.1	42.0	40.5	
LSD 0.05 (S)			1.5		
LSD 0.05 (V&S)			2.1		

Table 5 shows the effect of *Phaseolus* variety and stress on the mean number of days to first flower bud appearance. Days to the appearance of first flower bud was significantly longer in *Phaseolus coccineus* (P=0.05) than in *Phaseolus vulgaris*. In *Phaseolus vulgaris*, the longest days to the appearance of first flower bud occurred when stress was applied at the flowering stage but in *Phaseolus coccineus*, the longest number of days to the appearance of first flower bud occurred when stress was applied at the pod formation stage.

Across both types of *Phaseolus*, the longest period to the appearance of flower bud occurred when stress was applied at the flowering stages. In general, the differences in the first flower bud were not significantly different for the different stress periods.

Number Of Days To First Flower Appearance

Table 6: Effect of Variety and Stress on Mean Number of Days to First flower Appearance

Varieties	Mean
<i>Phaseolus vulgaris</i>	67.4
<i>Phaseolus coccineus</i>	112.5

Table 6 shows the mean number of days to first flower appearance. There was a great significant difference between the varieties with respect to mean number of days to first flower appearance. *Phaseolus coccineus* took longer to flower (112.5 days) compared to (67.4 days) for *Phaseolus vulgaris*.

Number Of Days To First Fruit Set

Table 7: Effect of Variety and Stress on Mean Number of Days to First Fruit Set

Varieties	Mean
<i>Phaseolus vulgaris</i>	41.4
<i>Phaseolus coccineus</i>	60.5

Table 7 shows the mean number of days to first fruit set. There was a significant difference between the varieties with respect to mean number of days to first fruit set. *Phaseolus vulgaris* took a shorter period to set fruits (41.4 days) compared to *Phaseolus coccineus* (60.5 days) to set fruits.

Number Of Pods Per Plant

Table 8: Effect of Variety and Stress on the Mean Number of Pods Per Plant.

Varieties	Stress Period				LSD 0.05
	Seeding Stage	Vegetative Stage	Flowering	Pod Formation	
<i>Phaseolus vulgaris</i>	8.3	10.1	8.0	6.9	9.3
<i>Phaseolus coccineus</i>	6.4	4.0	3.7	4.7	4.7
Mean	7.4	7.1	5.9	5.8	1.0
LSD 0.05 (S)			1.5		
LSD 0.05 (V&S)			2.1		

Table 8 shows the mean number of pods for the various *Phaseolus* types. There was a significant difference in the number of pods produced per plant by the two varieties. *Phaseolus vulgaris* bean had the highest number of pods per plant with a mean of (8.3) compared to *Phaseolus coccineus* bean with the mean of (4.7). Highest number of pods occurred in *Phaseolus vulgaris* when stress was applied at the vegetative stage but in *Phaseolus coccineus*. Highest number of pods per plants occurred when stress was applied at the seedling stage. Number of pods per plant were significantly reduced when stress was applied at the flowering and pod formation stages.

Number Of Seeds Per Pod**Table 9: Effect of Variety and Stress on Mean Number of Seeds per Pod.**

Varieties	Stress Period				LSD 0.05
	Seeding Stage	Vegetative Stage	Flowering	Pond Formation	
<i>Phaseolus vulgaris</i>	4.1	3.1	3.2	3.1	3.4
<i>Phaseolus coccineus</i>	3.3	4.5	6.5	4.9	4.8
Mean	3.7	3.8	4.9	4.0	1.1
LSD 0.05 (S)			1.4		
LSD 0.05 (V&S)			2.0		

Table 9 shows the mean number of seeds per pod for the two *Phaseolus* types when stress was applied at different stages of growth. With *Phaseolus vulgaris* the highest number of seeds per plant occurred when stress was applied at the seedling stage. With *Phaseolus coccineus* the highest number of seeds was applied at the flowering stage. However, there was no significant differences in number of seeds per pod irrespective of when stress was applied ($P=0.05$).

100 Seed Weight**Table 10: Effect of Variety and Stress on the 100-Seed Weight.**

Varieties	Stress Period				LSD 0.05
	Seeding Stage	Vegetative Stage	Flowering	Pond Formation	
<i>Phaseolus vulgaris</i>	35.5	49.0	35.5	35.5	38.4
<i>Phaseolus coccineus</i>	35.0	35.0	40.0	30.5	35.1
Mean	35.3	42.0	37.8	32.0	5.5
LSD 0.05 (S)				1.4	
LSD 0.05 (V&S)				2.0	

Table 10 shows that one hundred seed weight was significantly influenced by both stress and variety. *Phaseolus vulgaris* (L.) had a higher seed weight than *Phaseolus coccineus* (L.) and 100-seed weight was highest for *Phaseolus coccineus* (L.). When stress was applied at the flowering stage. This may be due to an error in the reading of the weight table 4.

Discussion and Conclusion

Both stress and variety (*Phaseolus* types) had significant effects on the outcome of the study. In *Phaseolus vulgaris* (L.) there was a long delay in the appearance of flower bud when stress was applied at the flowering stage. Similar effect was also observed with *Phaseolus coccineus* (L.) suggesting that stress at the reproductive stage was very critical to the formation of flowers. This finding is consistent with the report of Mackey and Eaves, 1962.

The effect of stress on number of pods had minimal effect when stress was applied at the seedling and vegetative stages in both types. The effect of stress on seed yield was least when stress was applied at the seedling stage. Application of stress at other stages of growth produced similar effect on the number of seeds per plant.

Based on the results, the researcher concluded that Phaseolus types when stressed at the flowering and pod formation stages these adversely affected number of pods per plant. Number of seeds per plant were not significantly different irrespective of the stage of growth of the crop at which stress was applied.

Suggestion

Application of stress at any period of growth affected the number of seeds per plant adversely. It is advisable therefore, to ensure adequate irrigation during flowering and pod formation stages of growth of this crop for maximum pod formation.

References

- Anonymous (N.D) *National economic*. Studysmarter.co.uk
- BoroA_ic, J., Romic, D., & Dolanjsk, D. (2000). *Growth and yield components of dwarf French bean grown under irrigation conditions*. Doi:17660/ActaHortc.2000.533.56
- Cambridge University Press (1968). Water Relations of beans I. effects of water stress on growth and flowering. *Experimental Agriculture*, 5(3), 195-207. <https://doi.org/10.1017/s0014479700004440>
- Byrne, P. (Fava bean (Vicia). Pressbooks.pub <https://clcstate.pressbooks.pub>
- Forsyth, E. Schofield, T. (2023). *Free market economy*. [https:// Ststudy.com](https://Ststudy.com)
- Greensill, T. M. (1968). *A guide for Tropical Gardners*. Evans Brothers Ltd pp 38-39
- Jana, D., Mohanta, S., Chatterjee, S., Arvind, T., & Behera, P. (2023). Evaluation of planting dates and varieties of pole type French bean (*Phaseolus Vulgaris* L.) in Sourthen Odisha. *Environment and Ecology* 41(4d), 3042-3048 DOI:<https://doi.org/10.60151/envec/FAER3114>
- Kivu, B. E., Asanica, A., Vinatoru, C., & Barcanu, E. (2021). Adwarf French bean-Anisia. Bulletin of University of Agricultural sciences and Vetenary. Medicine Clujj-Napoca. *Horticulture* 78(2:77. DOI:10.15835/buasvmcn.hort:0019.
- Kochhar, S. L. (1981). *Tropical crops*. New Delhi India. Macmillian publishers.
- Kriegbaum, H. (1955). Zur Frage der Ertragsanderung bei einigen Nutzpflanzen durch Bergnung zu verschiedenen Zeiten, Unter besonderer Beriicksichtigung der Ertrastuktur Von Winterweizen. *Z. Acker-U PflBau*, 100:99-132.
- Mackay, D. C. & Eaves C. A. (1962). The influence of irrigation treatments on yield and on fertilizer utilization by sweet corn and snap beans. *Canada Journal of plant Science*, 42:219-228.
- Manjeru, P., Madanzi, T., & Makedredza, B. Effects of water stress at different growth stages on yield and yield componenets of common bean (*Phaseolus vulgaris*) Doi.10.13140/Rg.2.1.2500.5924 Researchgate.net.
- Onwueme, I. C., & Sinha, T. D. 91991) Field crop production in tropical Africa. *CTA pp*. 299 305.
- Pandey, B. P. (1980). *An introduction to economic botany*. S. Chand & camp Ltd New Delhi 11100255
- Puseglove, J. W. (1968). *Tropical crops dicotyledons*. Longman p.304.
- Rai, A., Sharma, V. & Heitholt, J. (2020). Dry bean (*Phaseolus vulgaris* L.) Growth and yield response to variabl irrigation in the arid to semi-arid climate. *Sustainable Irrigation Strategies for Improving Crop Water Productivity*, 12(9),3851. <https://doi.org/10.3390/su12093851>
- Sari, D., Adak, A., Eker, T., & Toker, C. (2018). *The nutritional content of common beans (Phaseolus vulgaris L.) Landrances in comparison to modern varieties*. mdpi.com <https://doi.org/10.3390/agronomy809>.
- Stansell, J. R. & Smittie, D. A. (1980). Effects of irrigation regimes on yield and water use of snap beans (*Phaseolus vulgaris*). *Journal of American Society for Horticulture* Doi.21273/JASHS.105.6.869. Researchgate.net