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Assessment of Growth and Adaptation Rate of Mung Beans (*vigna radiata*) Planted in Different Planting Periods in Abagana, SouthEastern Nigeria

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Abstract: *Research was conducted to compare the growth characteristics, adaptation rate and attributes of mung beans (Vigna radiata) planted in different planting periods in Abagana, South Eastern Nigeria. The experiment was carried out at Bioresources Development Centre, Abagana, Anambra State, between February to April, May to July and August to October all in 2021. Mung beans seeds were planted using a planting distance of 30cm by 60cm in each planting period. The mung beans cultivated matured from nine to ten weeks after planting in each planting period and data was collected weekly in some phenotypic characteristics of the crop from the first week to the tenth week after planting. The highest mean values per plant of some agronomic characters collected from the field such as plant height (cm), number of leaves, length of leaves (cm), width of leaves (cm) and number of pods were 17.2cm, 18, 6.0cm, 4.8cm and 20 for those grown between Februaryto April while those grown between May to July were 35.4cm, 39, 14.6cm, 12.9cm and 37, and those of August to October were 34.6cm, 37, 13.8cm, 13.0cm and 35.There were no significant difference (P>0.05) between the mung beans planted from May to July and those planted from August to October with respect to the above agronomic characters. Significant difference (P<0.05) existed between the mung beans planted from February to April when compared with those of May to July and August to October with respect to the above-mentioned agronomic characters. The result of the data collected from the field which was used as the plant adaptation parameters suggested that the mung beans grown between May to July and August to October had a better adaptation to the planting periods when compared with those grown from February to April 2021*

Keywords:*Adaptation rate, mung beans, planting period, growth, agronomic characters*

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1.0 Introduction

Mung beans (*Vigna radiate*) is a leguminous plant belonging to the family Fabaceae. It is an early maturing crop andthe pod production per plant is high when compared with many other grains that have longer maturity time. Mung beans are believed to have originated from India. It is still spreading to different parts of the world so the best growing period is yet to be discovered in many parts of the world.

Mung beans can be planted throughout the whole year but they adapt most and perform better when cultivated at the right time and environment.Mung bean is adapted to tropical and subtropical low-lands and relatively tolerant to abiotic stresses, like drought and heat (Chankaew *et al*., 2014). The degree of adaptation of mung bean differs when cultivated at different time of the year partly due to changes in the climatic condition. Adaptation of cultivated mung beans can be better under favorable condition and can also be poor when the climatic condition is not favorable.

Mung beans are annual crop and each of their leaf stalk contains three leaflets which are oval to elliptical shaped in nature. The flowers of mung beans are also papilionaceous in nature.Cultivated mung beans manifests its natural and appropriate morphological characteristics such as sprouting time, number of leaves, length and width of leaves, increase in height, time of flower production, number of flowers, number of pods and time of its production etc. The above morphological characteristics may serve as parameters for measurement of plant adaptation rate to the cultivated environment. Plants that have good adaptation to the cultivated environment manifests better, healthy, natural and normal morphological characteristic while poor growth characteristics are evidence of poor adaptation. Mung beans crops have appropriate morphological characteristics assigned to the plant by nature. When these appropriate characteristics are met, the mung beans plant can have best adaptation to the cultivated environment.

The benefit of mung beans cannot be over emphasized and some are as follows; cooked seeds are food for diabetic patients. Their protein content can be compared with that of soya bean and they are safe because they are plant protein as they do not contain cholesterol. Mung beans contain high level of antioxidant activity (Shi *et al*., 2016). Their grinded seeds can be used in making cake and juice. Mung beans sprouts are sources of minerals and vitamins (Kyriacou *et al*., 2016). The succulent leaves and stem of mung beans can serve as forage for livestock.Mung beans forages (hays and straws) are part of the mung beans that are mainly used as feed for livestock. Decayed plant part can serve as green manure.Mung beans crops are not yet among the commonly grown crops by farmers partly due to lack of knowledge of some of these benefits, adaptability, early maturity time and high pod productivity.Though the crop is a drought tolerant plant, the adaptability of the plant at different planting periods is yet to be discovered. The above benefit can add to improve in the economy of a nation and standard of living of the populace.The potential contribution of mung beans to food security, its general use as a multi-purpose crop that could increase farmer's income and livelihoods, feed animals and possibly enhance soil fertility over time and also its adaptation strategies has been reported byPataczek *et al*. (2018). .

Mung beans production is still low to be compared to its expected future increase in demand of the grain and other parts of the crop (Sehrawat *et al*., 2015). It is important to improve the average world production of mung beans and also to expand its production to other regions such as Central Asia and Africa in order to meet its global demand and to address widespread malnutrition (Nair *et al*., 2015). These necessitate the study on the assessment of growth and adaptation rate of mung beans cultivated in different planting period. This is

to know the ability of the plant to withstand the different degrees of climatic conditions that occur in different period of the year.

2.0 Materials and Methods

An experiment was conducted by planting mung beans seeds at Bioresources Development Centre, Abagana, Anambra State, from February to April, May to July and August to October, all in 2021.Abagana is in the tropical savanna zone of South Eastern Nigeria with abundant trees, shrubs and grasses. It is located at latitude $06^0.11^1$N, longitude $06^0.59^1$ E and at altitude of 231m. The mean annual rainfall is about 1,700mm, the relative humidity ranges from 74% to 94% while that of temperature ranges from 24^0C to 34 ^{0}C.

The mung beans seeds (one packet) used for the experiment was obtained from Shoprite Super Market, Benin City, Edo State, Nigeria. The area of the field used for the experiment was 30 m by 30m. The field was ploughed, harrowed and ridged manually. Green manure (plant debris) was incorporated into the soil one week before land preparation in each experiment. Thirty ridges measuring 30m by 0.8m each was used in each experiment. Each ridge was 0.4m apart from each other. Mung beans seeds were planted one per hole at both sides of the ridge using the planting distance of 30cm by 60cm and a planting depth of 3cm. A total of six thousand seeds were planted in the whole field with each ridge containing two hundred stands.Different portion of land was used for each experiment. Water was added to the mung beans stands planted between February to April from first day of planting to fourteen days after planting due to lack rainfall that at the first two weeks of the period. The mean number of days to germination of the mung beans seeds was five days after planting. The crops were monitored to know their adaptability at each planting period from seedling to pod production and harvest.Data was collected from the plants throughout the experimental period.Weeding was done manually two times before harvesting.

Data was collected on weekly bases from the physical attributes per plant as follows: plant height (cm), number of leaves, width of leave from the middle (cm), length of leaves from the middle (cm), number of branches, number of flowers, number of pods, length of pods (cm), and number of seeds per pod. Also, data on days to seed germination and sprouting, days to branch production and days to flower production per plant were also recorded. The above data collected were the adaptation parameters used for the experiment. The plant height per plant, length of leave per plant, width of leave per plant and length of pods per plant were measured with meter rule. The number of leaves, number of branches, number of flowers, number of pods and number of seeds per pod was obtained by counting.

The data collected on each of the physical attribute of the plant was statistically analyzed to determine their mean at each planting period. The highest means of each agronomic trait was compared using Least Significant Difference (LSD) procedure at 5% significant level according to Obi (2002). to obtain the level of significant.

3.0 Results and Discussion

Tables 1 to 4 shows means of some weekly agronomic characters (adaptation parameters used) collected per plant from mung beans grown for some planting periods. In Table 1, the data represents the planting period covering February to April. From the presented results, the mean plant height increased from 4.3 cm in the first week to 17.2 cm by the tenth week. The number of leaves increased from 2 to 18, while the length and width of leaves grew from 3.3 cm and 1.6 cm to 6.0 cm and 4.8 cm, respectively. However, the branches started forming in the fifth week, and flowering began in the sixth week with an average of 3 flowers, peaking at 13 flowers by the tenth week. Also, pod development began in the sixth week, reaching a maximum of 20 pods per plant, with

an average pod length of 7.8 cm and 8 seeds per pod by the tenth week. The presented results indicated that the growth of mung beans planted between February to April was gradual, with significant progress in plant height, leaf development, and flowering from the sixth week onwards. The cooler and possibly less favorable conditions during this period may have contributed to the slower growth and lower yields compared to the other planting periods.

Data for the planting period extending from May to July were presented in Table 2, which shows that the plant height increased rapidly to 35.4 cm at the end of the tenth week. Also, the number of leaves showed an increment from 4 to 39, with leaf length and width increasing from 5.3 cm and 2.0 cm to 14.6 cm and 12.9 cm, respectively.Branching started in the fifth week. Flowering began in the fifth week with an average of 13 flowers, increasing to 22 by the ninth week. However pod formation started in the fifth week, reaching a maximum of 37 pods per plant with an average pod length of 13.0 cm and 12 seeds per pod by the tenth week.

Table 1: Means of some weekly (week 1 to 10) agronomic characters (adaptation parameters used) collectedper plant from mung beans grownfrom between February to April, 2021

Measurement/week	1	2	3	4	5	6	7	8	9	10
Mean Plant height (cm)	4.3	6.0	8.1	10.0	10.5	11.8	14.0	16.4	17.2	17.2
Mean Number of leaves	2	5	8	11	14	16	16	18	18	18
Mean Length of leaves (cm)	3.3	4.2	4.9	5.0	5.1	5.4	5.5	5.8	5.8	6.0
Mean Width of leaves (cm)	1.6	2.0	3.3	3.5	3.6	3.8	4.5	4.7	4.7	4.8
Mean Number of branches	0	0	0	0	1	1	1	1	1	1
Mean Number of flowers	0	0	0	0	0	3	5	8	11	13
Mean Number of pods	0	0	0	0	0	2	6	14	20	18
Mean Length of pods (cm)	0	0	0	0	0	2	4.1	6.8	7.4	7.8
Mean Number of seeds per pod	0	0	0	0	0					

Table 2 Means of some weekly agronomic characters collected per plant (adaptation parameters used) from mung beans grown between May to July, 2021

Measurement/week	1	2	3	4	5	6	7	8	9	10
Mean Plant height (cm)	5.0	8.5	10.8	13.2	25.5	29.0	31.4	33.1	34.6	35.4
Mean Number of leaves	4	8	14	24	27	31	35	35	38	39
Mean Length of leaves (cm)	5.3	6.5	8.6	10.6	12.0	13.1	13.8	14.1	14.1	14.6
Mean Width of leaves (cm)	2.0	3.4	6.3	9.2	12.4	12.6	12.6	12.7	12.7	12.9
Mean Number of branches	0	0	0	0	1	2	2	2	2	2
Mean Number of flowers	0	0	0	0	13	14	15	18	22	19
Mean Number of pods	0	0	0	0	9	14	27	37	37	37
Mean Length of pods (cm)	0	0	0	0	2.8	6.1	10	11	12.3	13.0
Mean Number of seeds per pod	0	0	0	0	3	5	9	10	11	12

Table 3: Means of some weekly (week 1 to 10) agronomic characters collected per plant (adaptation parameters used) from mung beans grown between August to October, 2021

Measurement (week)	1	2	3	4	5	6	7	8	9	10
Mean Plant height per plant (cm)	3.8	5.5	8.7	10.9	16.1	24.2	28.4	31.3	33.6	34.6
Mean Number of leaves per plant	2	4	7	10	14	20	27	34	37	37
Mean Length of leaves per plant (cm)	3.3	4.3	5.1	6.0	9.0	11.0	13.2	13.5	13.8	13.8
Mean Width of leaves per plant (cm)	1.1	2.0	3.1	4.2	7.0	9.4	12.1	12.5	12.9	13.0
Mean Number of branches per plant	0	0	0	0	1	1	1	2	2	2
Mean Number of flowers per plant	0	0	0	0	4	8	14	21	25	23
Mean Number of pods per plant	0	0	0	0	0	5	16	19	35	35
Mean Length of pods per plant (cm)	0	0	0	0	0	3.7	7.1	8.7	9.2	10.5
Mean Number of seeds per pod	0	0	0	0	0	2	5	8	9	10

Table 4: Comparison of the highest mean values of all the agronomic characters (adaptation parameters) obtained from the mung beans grown in the three planting periods

	February to April	May to July	August to October	LSD 0.05
Plant height (cm)	17.2b	35.4a	34.6a	14
Number of leaves	18b	39a	37a	16
Length of leaves (cm)	6.0b	14.6a	13.8a	5
Width of leaves (cm)	4.8b	12.9a	13.0a	6
Number of branches	1a	2a	2a	1.5
Day-to-branch production	32a	32a	32a	2.0
Number of flowers	13b	22a	25a	7
Days to flower production	38a	32a	32a	10
Number of pods	20b	37a	35a	19
Length of pods (cm)	7.8a	13.0a	10.5a	5.8
Number of seeds per pod	8a	12a	10a	4.4
Days to sprouting	6a	5a	5a	1.3

****Values with different alphabets along the vertical column are significantly different (P<0.05)**

It is indicated from the presented results that the mung beans planted from May to July exhibited the most vigorous growth among the three periods. The rapid increase in plant height, leaf size, and prolific flowering and pod development can be attributed to optimal conditions, including sufficient rainfall and warmer temperatures, which are critical for photosynthesis and overall growth.

Results on the performance of the plant during he planting period that covers Augus and October showed measured results that are presented in Table 3. The results indicated that the plant height grew to a maximum of 34.6 cm by the tenth week. The number of leaves increased from 2 to 37, with leaf length and width growing from 3.3 cm and 1.1 cm to 13.8 cm and 13.0 cm, respectively. Also, branching was observed from the fifth week while flowering started in the fifth week, peaking at 25 flowers by the ninth week.Pod formation began in the sixth week, reaching a maximum of 35 pods per plant, with an average pod length of 10.5 cm and 10 seeds per pod by the tenth week. From the presented results, The August to October planting period also demonstrated vigorous growth, slightly lower than the May to July period. The favorable conditions during this period supported robust vegetative and reproductive growth, resulting in high yields. The slight reduction compared to May to July might be due to diminishing daylight hours as the season progresses.

Table 4 shows data for a comparative analysis of the outcome of the different planting periods. Consequently, we observed that the May to July period resulted in the tallest plants and largest leaves, followed closely by the August to October period. The February to April period had the least growth, indicating less favorable conditions.There were no significant differences in the number of branches among the periods. However, flowering and pod development were more prolific in the May to July and August to October periods compared to February to April.. The May to July period had the highest pod and seed production, indicating optimal conditions for reproductive success. The August to October period also showed high yields, while the February to April period had the lowest yield.: For optimal growth and yield, planting mung beans during the May to July or August to October periods is recommended in Abagana, South Eastern Nigeria. These periods provide the best conditions for both vegetative and reproductive growth, ensuring higher yields.

The different planting periods had effect on the adaptation of the mung beans especially on plant height, leave area, flower production, pod and seed production. All the agronomic characteristics collected from the plants from first week to tenth week were not exactly the same at each week in the planting periods. These manifest the growth and adaptability of the plants at different planting period. The means of some weekly agronomic characters collected from mung beans planted from February to April, May to July and August to October all in 2021 were presented in Tables 1 to 3. The comparison of the highest mean values of all the agronomic characters obtained from the mung beans planted in the three planting periods were also presented in Table 4.

The mung beans planted from February to April produced shorterplants, lower number of leaves, flowers and pods, smaller width of leaves and lower number of seeds all on weekly basis Table 1. Also, only one branch was produced per plant at this period. The increase in the plant height at 2, 4, 6, 8 and 10 weeks after planting were 6.0cm, 10.0cm, 11.8cm, 16.4cm and 17.2cm indicative of slow growth.The mung beans planted at this period matured at the height of 17.2cm, mean number of 18 leaves and 4.8cm of leave length. The highest plant height and number of leaves obtained from February to April were almost half of those obtained from May to July and August to October.The lower number of flowers, pods and seeds produced at this period was equivalent to the shorter plants as affected by weather condition of theperiod. This planting periodof February to April had some little negative impact on the growth and adaptation rate of the mung beans. This made the growth of the plant to be stunted even though some pods and seeds were produced.

There was no significant difference (P>0.05) between the mung beans planted from February to April and those of May to July and August to October with respect to days to sprouting, days to branch production, days to flower production, number of branches, length of pod and number of seeds per pod. The planting period had no effect on the above characters.

The mung beans planted from May to July had the better performance with respect the adaptation and the plant response to the period even though the data collected from the plant were not significantly difference (P>0.05) with those planted from August to October. Significant difference (P<0.05) only existed between the mung bean planted from May to July and February to April with respect to plant height, leave length and width, and number of leaves, flowers and pods. Highest plant height (35.4cm), number of leaves (39), number of pods (37), length of pods (13cm) and number of seeds per pod (12) were recorded from the mung beans planted from May to July Table 4. This planting period of May to July had the highest positive effect on the growth and adaptation of the mung beans.

The mung beans grown from August to October ranked second with respect to the plant adaptation when compared with those planted from February to April and May to July. The first and the best performance with respect to the growth and adaptation was those planted from May to July while the third and the last performed mung beans crop in this experiment were those planted from February to April.The growth pattern (increase in height and leave area) can also be used to judge the adaptability of a plant. The mung beans crop grown between May to July and August to October had faster weekly growth rate.

The result on the days to sprouting, days to branch production, days to flower production, number of branches, length of pod and number of seed per pod that showed no significant difference (P>0.05) between the mung beans planted from February to April, May to July and August to October suggested that the different planting periods had no effect on above mentioned adaptation parameters. The reason may probably be because of the same variety of mung beans used in this experiment.Also, the different weather conditions in the different planting period had noeffect on the same variety of mung beans planted with respect to above mentioned parameters.

The higher leave number and luxurious shoot growth recorded from the mung beans crops planted from May to July and August to October suggested that weather condition in these planted periodsfavored the mung beans.Leave appearance and shoot growth were among the most signs of adaptation that can be observed in growing crops. The higher number and width of leaves in these planting periods made the crops to have more leave exposure to sunlight and more chances of photosynthesis which led to increase in flower, pod, seed production and also appropriate natural increase in height. Apart from more foods (pods and seeds) produced from the mung beans planted from May to July and August to October, the physicalappearance of the mung beans suggested healthier, beautiful and good looking an indicative of better adaptation to these planting period. This was in contrast to those of February to April that appeared scrawny and shorter which also suggested poor adaptation to the planting period but they only survived and produced pods and seeds. This also suggested that the poor adaptation recorded in the planting period of February to April made the mung beans not to reach their natural and appropriate height before producing flowers and pods due to less number and area of leaves exposed to sunlight. Georgis (2010) reported that mung beans are drought resistant crop and possess the ability to survive under scanty rainfall condition. The least adaptation recorded in the mung beans cultivated from February to April also suggested that environmental stress such as

water shortage in soil mostly occur at this planting period and this reduced the soil nutrient available to the mung beans.Scanty rainfall that occurred in February also contributed to the least adaptability of mung beans cultivated at this planting period. Nair *et al.*, (2015) reported that the surrounding environment can affect the concentration of minerals in mung beans lines. This also suggests that the adaptation rate of mung beans can be affected by the grown environment since the amount of nutrient present in a crop is what is needed for the growth of a crop.

The non-significant difference recorded from the mung beans planted from May to July and August to October especially with respect to the highest mean values of plant height, leave number and width indicated similar weather effect on the mung beans planted in these periods. The significant difference that existed between the mung beans planted from February to April and those of May to July and August to October especially with respect to the highest mean values of plant height, leave number and width was an indicative of different weather effect on the mung beans planted in these periods.Environmental condition in different time of the year can contribute to the adaptation of mung beans growth and performance. Mung beans can be grown on marginal lands where most plants perform poorly and their forages are also suitable for green manureand also that mung bean fixes the nitrogen present in the atmosphere to soil nitrogen making the land suitable for the growth of next crop (Dainavizadeh and Mehranzadeh, 2013).

4.0 Conclusion

An experiment was conducted to evaluate the growth and adaptation of mung beans (Vigna radiata) planted during three different periods: February to April, May to July, and August to October 2021, at Bioresources Development Centre, Abagana, Anambra State, Nigeria. The experimental field, measuring 30m by 30m, was prepared manually, and mung beans were planted with a spacing of 30cm by 60cm. Data was collected weekly on various agronomic characters including plant height, number of leaves, leaf dimensions, number of branches, flowers, pods, and seeds per pod. The collected data were analyzed to determine the mean values and to compare the highest means using the Least Significant Difference (LSD) procedure at a 5% significance level.

The results indicated that the planting period significantly affected the growth and adaptation of mung beans. The plants grown from May to July exhibited the most vigorous growth and highest yields, followed by those planted from August to October. The February to April period resulted in the least growth and yield, likely due to cooler and less favorable conditions. Specifically, mung beans planted from May to July achieved the highest plant height (35.4 cm), number of leaves (39), pod length (13.0 cm), and seed count per pod (12). This period's optimal conditions, including adequate rainfall and warmer temperatures, contributed to the superior growth and reproductive success of the mung beans.

Following the above results and conclusion, the following recommendations are proposed.

(i) For maximum growth and yield, it is recommended to plant mung beans in Abagana between May to July or August to October. These periods provide the most favorable environmental conditions for the crop's vegetative and reproductive development.

(ii) During the February to April planting period, additional irrigation should be considered to mitigate the effects of insufficient rainfall and cooler temperatures, which can hinder the growth and yield of mung beans.

(iii): Additional studies should be conducted to explore the impact of various agronomic practices, such as fertilizer application and pest control,

on mung bean production across different planting periods.

(iv) Incorporating green manure and other organic matter into the soil before planting can enhance soil fertility and support the growth of mung beans, especially during less favorable periods like February to April.

(v) Regular monitoring of weather conditions and soil moisture levels is crucial for timely interventions and ensuring optimal growth conditions for mung beans throughout the growing season.

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Compliance with Ethical Standards Declaration

Ethical Approval

Not Applicable

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Availability of data and materials

Data would be made available on request.

Authors' contributions

The first author was involved in conceptualization. The second to the fourth author carried out the fieldwork and methodology while the fifth and sisth authors: fieldwork and manuscript development.