Ilmu Pertanian (Agricultural Science)
http://journal.ugm.ac.id/jip
Vol. 7 No. 3 December, 2022: 152–159| DOI: doi.org/10.22146/ipas.72990

Improvement on yield of onion (*Allium cepa* L.) using different rates of organic manure and sowing seasons in South Eastern Nigeria

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Article Info

Received : 11st February 2022
Revised : 31st May 2022
Accepted: 11st July 2022

Keywords:
poultry manure, cropping seasons, bulb weight

Abstract

This study aimed at determining how different rates of poultry manure affected the growth and production of onions (*Allium cepa* L.) in wet and dry seasons. The experiment had been conducted from July to October 2019 and from January to April 2020 at the Department of Crop Science teaching and research farm, University of Nigeria Nsukka, South Eastern Nigeria. The experiment applied a randomized complete block design with nine replications spread over three blocks. The treatments were four doses of poultry manure (0, 10, 20 and 30 $t.ha^{-1}$) tried in two seasons (wet and dry season). Prior to the investigations, soil analysis of the experimental site and poultry manure nutrient content were carried out. The growth pattern and yield was higher during the wet season. Poultry manure at amount of 30 $t.ha^{-1}$ gave the best growth attributes (number of leaves, leaf length, and leaf diameter) 14.22, 53.67 cm and 0.88 cm respectively while the 20 $t.ha^{-1}$ had the highest plant height and bulb fresh weight, 60.86 cm and 2 kg/plant respectively. The trend was not the same as in dry season planting because 20 $t.ha^{-1}$ poultry manure differs significantly from other rates of poultry manure considered. Plant height, leaf length, leaf diameter and bulb fresh weight (57.64 cm, 55.28 cm, 0.84 cm and 0.63 kg/plant respectively) were statistically significantly ($p < 0.05$) different at 5% probability level. Utilization of 20 $t.ha^{-1}$ of poultry manure and planting in wet season gave the best growth and yield of onion vegetable.

INTRODUCTION

Since ancient times, onions have been widely recognized as food and medicine, making them a valuable crop around the world (Shigyo and Kik, 2008, Pareek et al., 2017). It is thought to be a member of the Alliaceae family and to have originated in Central Asia, specifically Afghanistan, where some of its relatives are still seen growing naturally (Bagali et al., 2012). Due to the antioxidant (phenolics) presence in onions, it has been known to lower heart diseases (Airaodion, 2020), control blood pressure (Edward et al. 2007) and reduce blood sugar (Lee et al. 2015). Nicastro et al. (2015) opined that it contains anti cancer properties while Pandey and Rizvi (2009) concluded that it cures digestive disorders and prolonged cough.

The bulbous vegetable crop may be grown professionally in most regions of the world, and onion farming is recognized to be a lucrative sector that employs a lot of labors (Havey and Ghavami 2018). They are traded extensively both within and between nations around the world (Plaisier et al., 2019). It is a significant spice and one of Nigeria's top five vegetables (FAO, 2017). It is a valuable crop with pungent flavor and this pungency of onion is as a result of the presence of a volatile compound known as allyl-propyl disulphide (Cramer et al., 2021). Onion is also a crucial component of the cuisine of many places, which is known as the "queen of the kitchen" and is practically always utilized in homes (Greeshma et al., 2020). China produces over

How to cite: Ishieze, P.U., Onah, C.F., and Dauda, N. (2022). Improvement on yield of onion (Allium cepa L.) using different rates of organic manure and sowing seasons in South Eastern Nigeria. *Ilmu Pertanian (Agricultural Science)*, 7(3), pp. 152–159.

ISSN 0126-4214 (print) ISSN 2527-7162 (online)

28 percent of the world's onions, followed by India, the United States, Iran, Egypt, Turkey, Russia, Pakistan, the Netherlands, and Brazil (FAO 2017). Out of 61.6 million metric tons of onions produced worldwide as estimated by FAO, Nigeria's average yield is 14.8 tons/ha (FAO 2017).

Manure is regarded as a crucial element that influences the development and production of plant, ultimately increasing plant yield (Gwari et al., 2014). Nutrients are known to greatly improve the productivity and quality of vegetable crops. Animal manures have been used as organic agricultural fertilizers since antiquity. Due to its high nitrogen content, poultry manure has long been considered one of the most attractive manures. Manure not only fertilizes crops but also provides additional vital plant nutrients and acts as a soil amendment by introducing organic matter, which enhances soil moisture and nutrient retention. Onions often have shallow and unbranched root systems, making them more vulnerable to nutrient uptake than most crops (Rizk et al., 2012, Hanci and Cebeci 2015). As a result, onions need fertilizers and frequently benefit from the addition of soil nutrients. Soil amendment is required in order to maintain the high yields. Additionally, onions require a lot of soil nutrients, particularly nitrogen and potassium. Consequently, organic manure application is required for the best growth and output (Gwari et al., 2014). The literature on onions in Nigeria is very sparse, while not being in stark contrast to many papers on the investigations of the effects of poultry manure on agricultural crops. Therefore, this study aimed to examine how cropping seasons and varying levels of poultry manure affected the growth and productivity of onions. To the best of our knowledge, this is the first investigation into how cropping seasons and levels of chicken manure affect the productivity of onions in South Eastern Nigeria. Different rates of chicken manure were expected to affect the growth and yield of onion, and additional research is still needed in this area.

MATERIALS AND METHODS

Description of study area

Field tests were carried out at the Department of Crop Science's teaching and research farm at University of Nigeria Nsukka's Faculty of Agriculture (07^o 29 N, 06^o 51 E and 447.26 m above sea level). Tropical lowland humid weather with a bimodal rainfall pattern that begins in late March and lasts until late October following a dry spell in August are what define Nsukka. With an average annual temperature of 29°C to 31°C and a relative humidity of 69% to 79%, Nsukka experiences rainfall within the range of 1155 mm to 1955 mm (Uguru et al; 2011).

Collection of soil and poultry manure for nutrient analysis

Soil was collected randomly from the experimental site using soil auger at 15cm depth. The soil samples were taken to the Department of Soil Science laboratory for analysis to ascertain the nutrients availability in the sample area. Furthermore, the poultry manure used was analyzed in the same laboratory to ascertain the nutrient content of the manure.

Collection of climatic data

The meteorological data on the temperature, relative humidity, rainfall distribution was collected from the Meteorological station of the Department of Crop Science during the period of experiment.

Evaluation of the effects of different rates of poultry manure on the growth and yield of onions planted during the rainy and dry seasons.

To evaluate the growth and yield of an onion variety (Red creole that adapts to diverse climatic condition and has a yield potentiality of 16 $t.ha^{-1}$ in Northern Nigeria), a field experiment was conducted under different manure rates 0, 10, 20 and 30 $t.ha^{-1}$ (Agu et al., 2015) during the wet and dry seasons (July to October 2019 and January to April 2020, respectively). The experiment was laid out in Randomized Complete Block Design (RCBD) with nine (9) replications in three blocks. Two weeks prior to transplanting, poultry manure was applied on already made beds (2 m × 2 m with inter-bed spacing of 0.5 m) to enable the decomposition of manure. The seedlings were transplanted after six weeks in the nursery with a spacing of 30 cm which gave rise to 12 plants per plot where four plants were sampled. Data on parameters of growth were collected at two-week interval for ten (10) weeks in total. The following data were collected:

Plant height : from the base of the plant to the tip of the leaf using a meter rule
Number of leaves : done by counting

Leaf length : from the pseudo-stem to the tip of the leaf using a meter rule
Leaf diameter : measured using a veneer caliper
Bulb weight at harvest : measured using a weighing balance

Data analysis

The collected data were put through analysis of variance (ANOVA) using Genstat statistical software of 10th edition version. Using Fisher's least significant test at a 5% probability level, mean separation was carried out (Obi, 2002).

RESULTS AND DISCUSSION

Environmental condition

The highest rainfall during the first experiment taking place between July and October was in September (309.23 mm), when the vegetable was approaching harvest. There was a sharp increase of rainfall from 145.28 mm in July to 264.38 mm in August. Rainfall started declining in October (30.99 mm). The fluctuations in temperature were also recorded between the mean and maximum temperature which ranged between 20 and 30°C. The meteorological data also showed that as the temperature was increasing, the relative humidity was decreasing and it ranged from 60–68%. During the second experiment (January–April), minimum amount of rainfall was recorded which ranged from 0.51 mm to 87.80 mm in April (87.80 mm), making it the highest and also the onset of rainfall in the experimental area. The temperature also ranged from 19 to 33.93°C. The relative humidity was lower during the second experiment (37–53.27%). The variations in the climatic condition in the tropics have altered the weather conditions of the study area. Rain normally starts in March, witnesses short spell in August, and stops in October (Uguru et al., 2011). From the data collected, the rain was recorded throughout the month, with different duration.

Properties of field (soil) and poultry manure

The analysis of initial soil properties prior to treatment application for this experiment indicated that the soil is loamy soil in texture, slightly acidic (pH = 5.1), rich in P, but deficient in N, K, organic carbon and organic matter (Table 2). The poultry manure was low in N.P. and K, but abundant in organic matter.

Effects of different rates of poultry manure on growth and yield of onions in different seasons

It is evident in Figure 1 and 2 (rainy and dry seasons, respectively) that the effect of poultry manure doses on plant height at 0, 10, 20 and 30 $t.ha^{-1}$ was statistically significant ($p < 0.05$). The figure reveals that there was significant differences in two weeks, four weeks, six weeks, eight weeks and ten weeks after transplanting and 20 $t.ha^{-1}$ of poultry manure dose gave the highest value in the eighth week after transplanting for rainy and dry seasons, respectively (60.86 cm and 57.64 cm) while 0 $t.ha^{-1}$ gave the lowest value at the same week after transplanting (34.75 cm and 35.08 cm). Diverse poultry manure doses significantly ($p < 0.05$) affected the quantity of leaves formed by the onion plants in various weeks after

Table 1. Data of weather for the trial site for the growing seasons of 2019 and 2020

Month	Rainfall (mm)	Temperature (°C)		Relative humidity (%)
		Min	Max	
July (2019)	145.28	20.29	28.65	62.52
August	264.38	21.16	27.38	62.45
September	309.23	21.93	29.07	60.30
October	30.99	30.00	20.00	58.00
January(2020)	0.51	19.43	32.07	37.07
February	10.67	21.71	33.93	38.36
March	17.02	22.84	33.77	46.06
April	87.80	23.03	33.30	53.27
Total	865.88	180.39	238.17	428.03
Mean	108.24	22.55	29.77	53.58

Remarks: Source from Department of Crop Science, University of Nigeria Nsukka's meteorological station.

Table 2. Chemical parameters of the test site's soil (0–30 cm depth) and characteristics of the poultry manure utilized and 2020

Soil mechanical/chemical properties	Soil particle size	Poultry manure
Textural class	LS (loamy soil)	-
Clay (%)	16.00	-
Silt (%)	9.00	-
Fine sand (%)	37.00	-
Coarse sand (%)	38.00	-
Carbon (%)	1.207	27.83
Organic matter (%)	2.082	77.98
Nitrogen (%)	0.098	2.172
Sodium (meq/100 g soil)	0.04	0.93
Potassium (meq/100 g soil)	0.09	0.13
Phosphorus (ppm)	30.28	0.41
Cation exchange capacity (meq/100 g soil)	11.60	-
Hydrogen (H^+)	5.60	-
Aluminium (Al^{2+})	1.00	-
Base saturation (%)	33.88	-
Available phosphorus (ppm)	7.46	-
pH in H_2O	5.10	-
pH in KCL	4.00	-
Total Si	2.07	-

Remarks: Source from Department of Crop Science, University of Nigeria Nsukka's meteorological station.

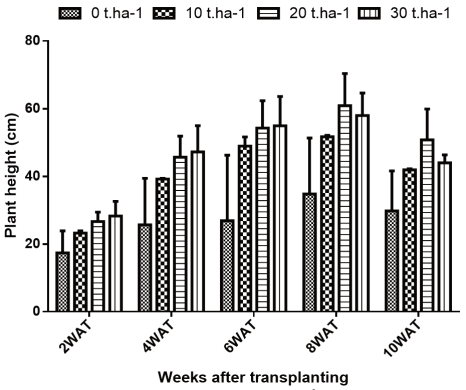

Figure 1. Effect of manure rate (t.ha^{-1}) on plant height during the rainy season

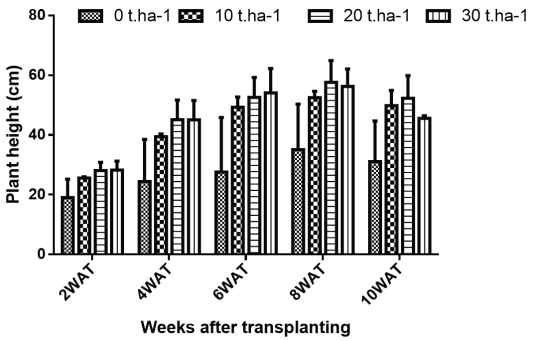

Figure 2. Effect of manure rate (t.ha^{-1}) on plant height during the dry season

transplanting (Fig. 3 and 4). 30 t.ha^{-1} gave the highest quantity of leaves in two weeks, four weeks, six weeks and eight weeks (5.36, 8.42, 12.17 and 14.22) respectively for rainy season but 10 weeks after transplanting 20 t.ha^{-1} gave the highest quantity of leaves (12.53). It did not follow the same trend as the dry season planting. Poultry manure at the amount of 20 t.ha^{-1} gave the highest number of leaves in the two and four weeks after transplanting (6.72 and 10.75) while the 30 t.ha^{-1} did better in six, eight and ten weeks after transplanting (15.58, 16.50 and 11.08).

The leaf length was significantly ($p < 0.05$) affected by poultry manure dose, as seen in Figures 5 and 6. It indicates that the leaf length was significantly different from each other in two, four, six, eight and ten weeks after transplanting and 30 t.ha^{-1} of poultry manure dose gave the highest leaf length in eight weeks after transplanting (55.39 cm). Poultry manure at the amount of 0 t.ha^{-1} gave the lowest value (34.79 cm). In dry season, 20 t.ha^{-1} of poultry manure gave the highest leaf length (55.25 cm) while 0 t.ha^{-1} gave the least one (30.58 cm). The leaf diameter presented

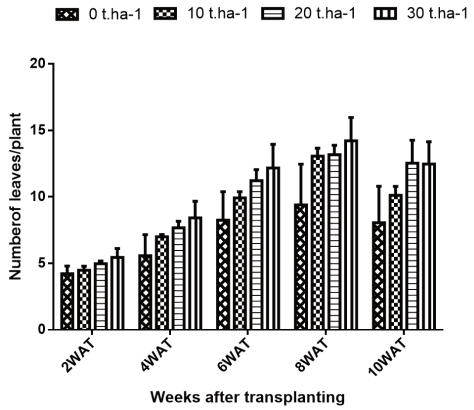

Figure 3. Effect of manure rate (t.ha^{-1}) on number of leaves during the rainy season

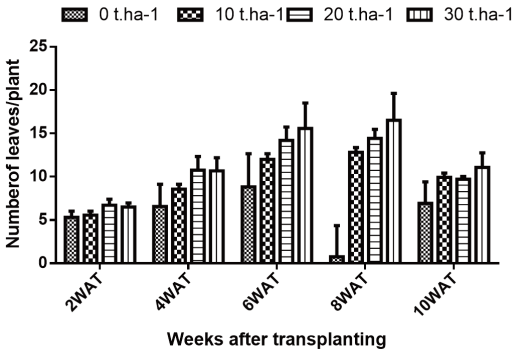

Figure 4. Effect of manure rate (t.ha^{-1}) on number of leaves during the dry season

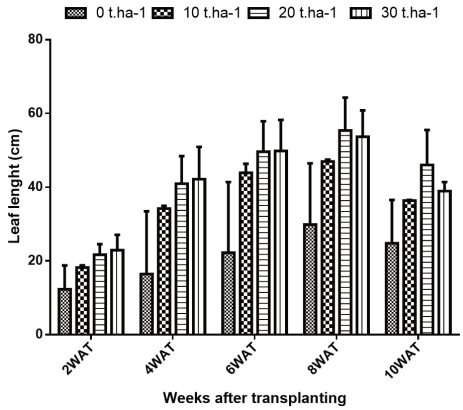

Figure 5. Effect of manure rate (t.ha^{-1}) on leaf length during the rainy season

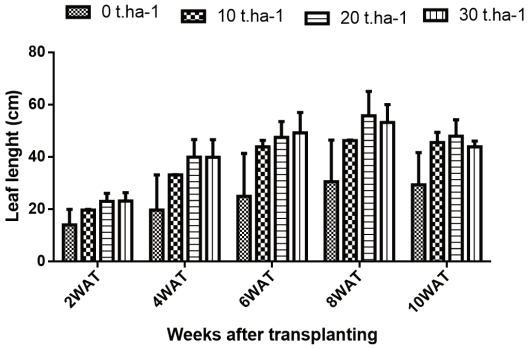

Figure 6. Effect of manure rate (t.ha^{-1}) on leaf length during the dry season

on figure 7 and 8 show that the leaf diameter ($p < 0.05$) differed in different doses of poultry manure in two, four, six, eight and ten weeks. In the tenth week after transplanting, during the rainy season, thirty tons per hectare of poultry manure dose produced the highest leaf diameter (0.88 cm) while 0 t.ha^{-1} gave the lowest one (0.61 cm). It is different in dry season as 20 t.ha^{-1}, (0.84 cm) did better than 30 t.ha^{-1} (0.76 cm) while the 0 t.ha^{-1} gave the least leaf diameter (0.72 cm). Figure 9 and 10 show the effects of different doses of poultry manure on yield. Bulb weight significantly ($p < 0.05$) differed at harvest. The highest bulb weight was observed at twenty tons per hectare of poultry manure dose after harvest (2.00 kg/plant, 24 kg/ plot, and 60000 kg.ha^{-1} in rainy season), while zero tons per hectare of poultry manure gave the lowest bulb weight at harvest (0.60 kg/plant, 7.20 kg/plot, and 18000 kg.ha^{-1}). However, in dry season planting, 20 t.ha^{-1} had the highest bulb weight at harvest (0.63 kg/plant, 7.60 kg/plot and 19000 kg.ha^{-1}), while the 0 t.ha^{-1} gave the lowest yield (0.22 kg/plant, 2.92 kg/plot and 7300 kg.ha^{-1}). From the above results, we can deduce that bulb weight was more increasing at harvest during rainy season than during dry season.

It was unknown how various poultry manure doses and the planting seasons affected onion output in relation to one another. In order to determine the effects of various poultry manure doses and planting time on onion output, the current study was carried out. Throughout the study period, the 20 and 30 t.ha^{-1} doses of poultry manure produced the highest value for all vegetative features, which may be related to the rapid rate of nutrient release from the manure. This favorable response to the degree of manure treatment being increased may be attributed to the fact that onion plants have shallow roots that are rarely branched and devoid of root hair, which has led to a high demand for nutrients. The main cause of the rise in measured parameters due to greater application of manure may be related to the increased availability of total assimilates for distribution to the bulb and shoot, as well as the rise in dry matter. The lowest

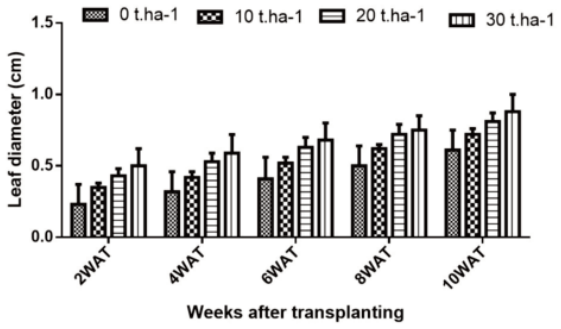

Figure 7. Effect of manure rate (t.ha^{-1}) on leaf diameter during the rainy season

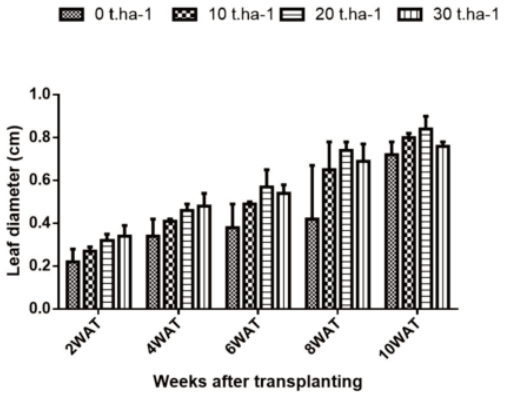

Figure 8. Effect of manure rate (t.ha^{-1}) on leaf diameter during the dry season

Table 3. Average yield of onion per plant, per plot, and per hectare

Manure rate	Fresh bulb weight (kg)					
	Rainy season			Dry season		
	Per plant	Per plot	Per hectare	Per plant	Per plot	Per hectare
0 t.ha^{-1}	0.60 a	7.20 a	18000 a	0.22 a	2.6 a	6500 a
10 t.ha^{-1}	1.26 b	15.11 b	37783 b	0.35 b	4.2 b	10500 b
20 t.ha^{-1}	2.00 c	24.00 c	60000 c	0.63 c	7.6 c	18000 c
30 t.ha^{-1}	1.89 c	22.67 c	56667 c	0.60 c	7.2 c	19000 c
F-LSD (0.05)	0.439	5.276	13190.7	0.132	1.583	3957.7
Multiple R	0.789	0.788	0.788	0.813	0.807	0.807
R^2	0.622	0.622	0.621	0.661	0.651	0.651

results obtained from the control indicates that tropical soils lack some essential elements for plant growth and high yield, necessitating the addition of additional fertilizers to the soil to meet crop needs. The onion plant height was raised in several growing stages by the application of poultry manure. In most cases, plant height climbed moderately for the first eight weeks after transplanting before rapidly declining because of leaf senescence. While the control treatment resulted in the shortest plant, the tallest plant was discovered in 20 t.ha^{-1} at 8 weeks (60.86 cm) followed by 30 t.ha^{-1}. The apical meristem of the shoot, which was stimulated by the provision of balanced nutrients underwent cell division, leading to a rise in plant height. This was in line with the findings of Ali et al. (2018), who noted a considerable increase in plant height as a result of applying poultry manure. In all sampling periods, the number of leaves was the highest in the application of 20 t.ha^{-1} and 30 t.ha^{-1} and the lowest when using control. The number of leaves increased up to 8 WAT and thereafter decreased to 10 WAT. This might probably be due to the maturity exhibited by the plant. This is in line with the findings of Khan et al. (2002), who found that the number of leaves per plant was higher in plots treated with cow dung up to a point and then decreased, as reported by Bashir et al. (2015). Additionally, Amos et al. noted a similar response. Dhaker et al. (2017) brought up the result on the application of manure leading to luxuriant vegetative growth of crops and emphasizing the significance of nutrients during this period, which would be reflected in the metrics, such as number of leaves, leaf area, and plant height generated. Red Creole's increased leaf length, diameter, and steady growth in response to poultry manure which may be explained by the release of macro and micro nutrients by the manure during the process of microbial decomposition. The poultry manure contains nutrients like N.P.K. that enhance crop development and yield. This outcome is consistent with those of Agbede et al. (2008) who discovered that there was a direct correlation between the concentration of poultry droppings and the quantity of crop leaves. Dapaah (2014) and Babajide et al (2008) in their work on onion indicated that optimal growth and development at early stages of growth necessitate quite a large

dose of nutrition. The leaf length and leaf diameter decreased in 10 weeks due to maturity of the onions. The highest bulb weight was obtained in 20 $t.ha^{-1}$ at harvest and this outcome is consistent with the research done by Mousa and Mohammed (2009), who opined that adding poultry manure increased the yield of onions. Ibrahim (2012) further mentioned poultry manure as promoting the plant development and bulb weight when sprayed at recommended rate. According to Adewale et al. (2011), poultry manure improved the soil's nutritional quality and increased the output of onions. Yeptho et al. (2012) stated that the onion production was boosted by the use of poultry manure. Referring to all of these findings, onions can be finely adapted to the South Eastern Nigeria as it showed that onion plant parameters increased significantly along with the increase in rate of poultry manure of 20 $t.ha^{-1}$ which produced the highest yield. It is therefore recommended that farmers who wish to invest in onion production should apply organic fertilizer poultry manure precisely at the rate of 20 $t.ha^{-1}$ for maximum growth and yield.

CONCLUSIONS

The result of this study showed that onion plant parameters increased significantly along with the increase in poultry manure rate of 20 $t.ha^{-1}$ that produced the highest yield. The research also showed that greater yield was recorded during the rainy season. It is therefore recommended that farmers who wish to invest in onion production should apply poultry manure on the rate of 20 $t.ha^{-1}$, for maximum bulb weight (60000 and 18000 $kg.ha^{-1}$ in rainy and dry season respectively). From this study environment, it is also recommended that the best season for production is in rainy season.

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