PERFORMANCE OF QUALITY PROTEIN MAIZE VARIETIES IN TWO ECOLOGICAL ZONES OF NIGERIA

By

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ABSTRACT

This research was carried out to test the utilization of water and soil nutrient by different Quality Protein Maize varieties. Field experiment was conducted in the 2008 and 2009 cropping seasons at the Ahmadu Bello University Institute for Agricultural Research (IAR) experimental fields in Samaru, Zaria and Kadawa, Kano state. The station at Samaru, Zaria is located in the northern Guinea Savanna while that of Kadawa is located in the Sudan Savanna of Nigeria. Complete Randomized Block Design (CRBD) was used as the experimental design. Duncan Multiple Range Test and soil physicochemical analysis were used to compare the potentials of different QPM varieties at two different research stations to convert soil nutrient and water into crop and vegetative yields. DMRT was used to compare the means of the treatments under investigation. Soil physicochemical analysis was carried out to analyze the soils of these research fields to determine the relationship between soil fertility in the presence of rainfall and the vegetative and crop yields of six QPM varieties. Dry matter weight revealed a higher mean weight of 148.3g in 2008 and 191.1g in 2009 in Kadawa compared to 132.1g in 2008 and 147.9g in 2009 in Samaru that has a much higher annual rainfall. Analysis of 100-seed weight revealed that the higher the amount of rainfall, the higher the 100-seed weight. Crop yield revealed a far superior performance in Samaru with a much higher annual rainfall compared to Kadawa. Replicates 2 and 1 in Samaru and Kadawa respectively produced the highest crop yields, which could be attributed to their soils. DMRT selected varieties six (Sammaz 17) and four (Flint Q) as the most recommended in terms of crop yield in Samaru and Kadawa respectively.

Key words: Complete randomized block design, Duncan multiple range test, Quality protein maize, Soil nutrient

INTRODUCTION

In Nigeria, maize is a major cereal crop for livestock feed and human consumption. Despite its widespread use across the country however, maize consumed in Nigeria is the normal maize. Unlike other West African countries such as Ghana, the adoption and cultivation of Quality Protein Maize (QPM) is still low in Nigeria (Jaliya, Falaki, Mahmud and Sani, 2008)

Agriculture depends largely on the success of plant reproduction. Reproductive products like grains, fruits, many vegetables and nuts are the bulk of the food supply. In United States of America (USA), more than 75% of the harvested acreage is devoted to such crops (Agriculture

Statistics, 1999). The success of reproduction is determined largely by environmental conditions prevailing during the growing season (Boyer, 1982).

FAO (2010) pointed out that early reproduction in maize is highly phasic, with each phase showing susceptibility to water deficits. Sinclair (1990) collected data from many maize plots subjected to water deficits and found a positive correlation between water deficit and kernel yields and shoot's dry matter accumulation. Thus, it is now well established that, water deficit reduces plant growth by decreasing leaf area, net CO_2 assimilation rate, transpiration rate, closure of stomata, chlorophyll fluorescence, lower chloroplast activity and nutrient imbalance (Akram, Shabaz and Ashraf, 2007; 2008; Ashraf, Nawazish and Athar, 2007; Ali, Ashraf, Shabaz, and Humera, 2008)

Furthermore, plant growth directly depends on availability of water and the water use efficiency (Edward and Walker, 1983) and determines photosynthetic rate (Ehleringer and Monson, 1993). It is important also to note that soil plays a very important role in determining soil uptake and use and Water Use Efficiency (WUE). Thus, salinity, due to over-accumulation of NaCl, is usually of great concern and the most injurious factor in arid and semi arid regions. More than 800 million hectares of land throughout the world are salt-affected (FAO, 2008). Their genesis may be natural, through irrigated agriculture, the intensive use of water combined with high evaporation rates and human activity (Lambers, 2003). NaCl-salinity causes reduction in carbohydrates supplied mainly through the process of photosynthesis (Parida and Das, 2005). In addition, a decline in the rates of net photosynthesis leads to a decrease in nutrient uptake and finally, growth of plants (Turan, Abdelkarim, Taban and Tanan, 2009).

Furthermore, maize grows on a wide variety of aerated, deep, sandy loams and silty loams containing adequate organic matter and it can tolerate soil pH from 5-8 but does best under pH 6-7 (Purseglove, 1972). Similarly, maize will grow on a wide range of soil types, provided they are well drained. A pH of 5-8 can be tolerated but best growth is achieved in the range of pH 5.6-7.5 (Queensland Government, 2010).

Normal maize's average protein content is about 2% lysine that is less than half of the concentration recommended by FAO (FAO, 2008). Hence, according to United Nation Development Programme (UNDP), almost one billion people living in the developing countries are malnourished and do not consume enough protein for good health (FAO, 2002). Furthermore, *Centro Internacional de Mejoramiento de maiz y Trigo* (CIMMYT) reported that the problem is that diets high in maize lack two essential amino acids (lysine and tryptophan) needed to prevent malnutrition (CIMMYT, 1988)

Quality protein maize, or "QPM", originally developed at CIMMYT contains nearly twice as much usable protein as other maize grown in the tropics and yields substantially more grain than traditional corn (Inuwa, 2001). Furthermore, CIMMYT (1988), Lawlor (2002) and Durbey (2005) observed that there is a superior performance of QPM compared with normal maize.

QPM's benefits results mainly from its lysine and tryptophan, but they go far beyond that. Although QPM has about the same amount of protein as common maize, it has about twice the usable protein because the quality and biological value of common-maize protein is equal to about 40 percent of the biological value of milk protein, whereas the biological value of QPM protein is about 90 percent of that of milk protein. Thus, QPM's nutritional benefits approach those of milk protein, a common standard of nutritional excellence (CIMMYT, 1988). However, before a crop variety is adopted, its yield potential and reactions to environmental conditions and diseases in the target environment must be evaluated (Jaliya *et al.,* 2008).

Thus, it is important to study how water and soil affect the crop and vegetative yield of different QPM varieties which is the aim of this study. Therefore, the aim of this research will be achieved by examining the effect of rainfall on the crop and vegetative yield of some QPM varieties, evaluate the effects some soil physicochemical properties that influence growth and yield of QPM and compare the effects of rainfall and soil physicochemical properties on QPM in the two research stations

STUDY AREA

The station at Samaru, Zaria (11^{o} 11$^{/}$N, 07^{o} 38$^{/}$E and 686m above the sea level) is found north of the deciduous forest zone. The grasses found here are usually very tall receiving up to 1000mm of rainfall annually in not less than 5-6 months. Tall grasses are interspersed with trees. The presence of river valleys makes it possible to derive some tall trees. The major agriculture practice includes the cultivation of grain crops and some fruits (Iloeje, 2001)

The station at Kadawa (11^{o} 39$^{/}$N, 08 02$^{/}$E and 500m above sea level) is found immediately north of the Guinea savanna and it has grasses as the dominant vegetation. The grasses found are shorter in size than those found into the Guinea savanna due to decrease in the amount of rainfall to about 600mm and the duration of rainfall is about 4 months. The major trees found here include acacias, dumb-palms, fan-palms and shea butter (Iloeje, 2001).

MATERIALS AND METHODS

Field experiment was conducted in the 2008 and 2009 cropping seasons at the Ahmadu Bello University Institute for Agricultural Research (IAR) experimental fields in Samaru, Zaria and Kadawa, Kano state. The station at Samaru, Zaria (11^{o} 11$^{/}$N, 07^{o} 38$^{/}$E and 686m above the sea level) is located in the northern Guinea Savanna while that of Kadawa (11^{o} 39$^{/}$N, 08 02$^{/}$E and 500m above sea level), is located in the Sudan Savanna of Nigeria.

A composite soil sample of the experimental site was taken for one depth (0-15cm) for pH, organic carbon and particle size analysis. Rainfall data and other meteorological information needed were collected from the meteorological station at IAR, Samaru and Kadawa respectively.

The experiment consisted of six QPM varieties that were planted after the establishment of rainfall at the experimental sites. The treatments include; CM 2007 POOL Y QPM (Variety 1), POP 66 SR/ ACR-91 SUWAN-1-SRC$_{1}$/ ACR 91 SUWAN-1-SRC (Variety 2), SAMMAZ 14 (Variety 3), FLINT Q (Variety 4), DENT Q (Variety 5), SAKATIFU /SAMMAZ 17 (Variety 6). The treatments were laid out in a Complete Randomize Block Design (CRBD) and the entire treatment was replicated three times. The plot size was 5m by four rows of ridges with a total gross size of 0.1 hectare. The cultural practices include; land preparation, sowing and fertilizer application, crop protection/ weed control and harvesting.

Five randomly tagged plants in each plot were used for periodic observation during the crop growth period. The results from the two years field research were computed and compared with their soils. The replicate with the best soil and yield were identified in the two stations and their results used for analysis. Data collected include among others; dry matter weight, 100-seed weight and crop yield which are the focus of this article. Harvesting was carried out each season when fifty per cent of the cobs showed signs of drying while laboratory analysis was carried out to determine particle size and the organic carbon contents of the soils where the research was carried out. The data from the experiment was analyzed using Duncan Multiple Range Test that compares the means of such treatments (Duncan, 1955) while tabulation and other descriptive statistics were used in presentation of findings.

RESULTS AND DISCUSSION

Table 1 looks at the physicochemical properties of the soils in the study area taking the account the replicates found in each of the fields. Thus, the textural class and the organic matter content were taken into account.

Table 1: Physical and Chemical Properties of the soil (0 – 15cm) at the Experimental Site in Samaru and Kadawa during 2008 and 2009 rainy seasons

Replicates	Textural class		Organic matter content			
			Organic matter	Organic carbon	Organic matter	Organic carbon
	2008	2009	2008		2009	
Replicate 1 (Samaru)	Sandy loam	Sandy loam	0.98	1.69	1.04	1.79
Replicate 2 (Samaru)	Sandy clay loam	Sandy clay loam	1.10	1.90	1.16	2.00
Replicate 3 (Samaru)	Sandy loam	Sandy loam	0.85	1.47	0.90	1.55
Replicate 1 (Kadawa)	Loamy sand	Loamy sand	1.30	2.24	1.36	2.34
Replicate 2 (Kadawa)	Sandy loam	Sandy loam	0.80	1.38	0.84	1.45
Replicate 3 (Kadawa)	Sandy loam	Sandy loam	0.78	1.34	0.82	2.10

Source: Soil sample as analyzed at Soil Science Department, IAR/ A.B.U, Zaria

Black (1965) stated that to deduce the amount of organic matter in a soil sample, it is expedient to multiply the organic carbon content by 1.724. Therefore, organic carbon content of a soil can also be deduced by dividing the organic matter content by 1.724 also. Therefore, Table 1 shows the physicochemical properties of the soils in Zaria and Kadawa. In Samaru, replicate two had the highest organic carbon and organic matter content while it was replicate one in Kadawa. Both replicates produced the best results in both years and in both stations. Like organic carbon and organic matter content, replicate two and one in Zaria and Kadawa respectively produced the best soil texture and the best yield in their individual stations. Thus, the organic matter content of a soil is closely related to soil texture because it prevented the leaching of water from rainfall and soil nutrient and yield is a product of the three.

The effect of rainfall and soil nutrient on dry matter is presented on Table 2. At Kadawa in 2008, total rainfall of 170.5mm of rainfall was recorded before sowing and 441.7mm between sowing and harvest (612.2mm in total) while in 2009, 230.7mm of rainfall was recorded before sowing and another 559mm at harvest (789.7mm in total). The difference in the amount of rainfall recorded between the two years was 177.5mm.

Table 2: The Effect of Rainfall and Soil Nutrient on the Dry Matter Weight of QPM Varieties in Zaria and Kano in 2008, 2009 and the Combined

TREATMENT	Samaru	Kadawa	Samaru	Kadawa	Samaru	Kadawa
Varieties	**2008**		**2009**		**Combined**	
CM 2007 POOL Y QPM	**149.92**	**154.62**	**168.45**	**199.20**	**159.18ab**	**177.19ab**
POP/91 SUWAN-1-SRC	**125.14**	**116.85**	**140.61**	**150.97**	**132.88ab**	**133.91b**
SAMMAZ 14	**127.33**	**167.56**	**143.07**	**216.49**	**135.20ab**	**192.03a**
FLINT Q	**169.46**	**137.70**	**190.40**	**177.90**	**179.93a**	**157.80ab**
DENT Q	**100.12**	**164.97**	**112.50**	**213.13**	**106.31b**	**189.05a**
SAMMAZ 17	**120.62**	**145.75**	**134.53**	**188.31**	**127.58ab**	**167.03ab**
Mean	**132.10**	**147.90**	**148.26**	**191.08**	**140.18**	**169.50**
SE±	**14.37**	**12.48**	**16.21**	**16.12**		
Significance	**NS**	**NS**	**NS**	**NS**	*	*

Means followed by the same letter(s) within each column are not significantly different at 5% significant level using Duncan's Multiple Range Test. **NS: Not significant * Significant**

On the other hand, 350.4mm was recorded before sowing in Samaru in 2008 and another 820.7mm at harvest (1171.1mm in total) while in 2009, 310.3mm of rainfall was recorded before sowing and another 967.7mm at harvest (1278.0mm in total). Therefore, the difference in the amount of rainfall recorded between the two years was 106.9mm.

From Table 2, no significant difference in dry matter weight was observed among the varieties in both stations. Therefore, the varieties were found to have a similar response to available moisture and soil nutrient in each of the two stations. Thus, all the varieties showed similar soil nutrient and water use efficiency.

However, FLINT Q had the highest weight in Samaru while it was SAMMAZ 14 at Kadawa in 2008 and 2009 rainy seasons. The mean derived from all the varieties in Kadawa was observed to be higher than that of Samaru in both years also. This could be attributed to rainfall, textural class (which prevented the leaching away of water and soil nutrient) and the great amount of residual nitrogen found in the soil at Kadawa. This supported the observation reported by Jones (1985) and Sharpley *et al*. (1994). It further clarifies the argument between Birch (1960), Semb and Garberg (1969) in favor of Birch (1960) who made mention of the immense importance of available Nitrogen in the soil.

Therefore, considering the amount of rainfall recorded between the two years in Samaru as 106.9mm on one hand and 177.5mm in Kadawa in relation to the result obtained, the result above further substantiate the soil nutrient and water use efficiency and the photosynthetic capacity of all the varieties under observation. The findings of CIMMYT (1988), Lawlor (2002), Durbey (2005) that there is a superior performance of QPM compared with normal maize is corroborated by this study.

The average rainfall recorded in Samaru at harvest for the two years under observation was 1224.6mm and 702mm in Kadawa. Therefore, the difference between the two stations was 522.6mm. Thus, considering the mean of each of the varieties in the combined analysis, a significant difference was then observed among the varieties in each station. With this, FLINT Q and SAMMAZ 14 in Samaru and Kadawa respectively still produced the highest dry matter weight. This proves that the soil nutrient and water use efficiency of certain varieties exceed that of other varieties. This further confirms the statement of Jaliya *et al.* (2008) that QPM varieties should be evaluated before dissemination to local farmers.

The effect of rainfall and soil nutrient on 100-seed weight is presented on Table 3. With the same amount of rainfall as Table 2, a significant difference in 100-seed weight was observed among the varieties in Samaru that had a much higher annual rainfall in both years. Therefore, the six varieties responded differently in their soil nutrient and water use efficiency as observed in their 100-seed weight. In Kadawa on the other hand, with a much lesser annual rainfall compared to Samaru, no significant difference was observed among the varieties in both years which shows that the soil nutrient and water use efficiency of the varieties were similar. The mean derived from all the varieties was found to be higher in Zaria.

Therefore, considering the rainfall amount between the two stations in relation to the results from the two years of observation, the varieties were observed to have a similar soil nutrient and water use efficiency in the development of their seeds/grains in an area having a lesser amount of rainfall (less than 800mm). The result was the opposite in Samaru which has an annual rainfall of over 1000mm. It therefore means that amount of rainfall is positively correlated with Water Use Efficiency (WUE). This could be supported by Edward and Walker (1983), Ehleringer and Manson (1993), Lawlor (1995) and Natr and Lawlor (2005).

With the same amount of rainfall as Table 2 above, and considering the mean of each of the varieties to arrive at the combined analysis, a significant difference was again observed among the varieties in Samaru, which has a much higher annual rainfall. This further substantiates the assumption that the results obtained are a product of annual rainfall amounts.

In all cases (2008, 2009 and the combined rainy seasons), varieties DENT Q and FLINT Q in Samaru and Kadawa respectively produced the highest 100-seed weight. The mean derived from all the varieties in Samaru with respect to 100-seed weight was much higher than that in Kadawa. In fact, Kadawa was only 53.3% of Samaru. This supported the observation by Kyari (1989) and FAO (2010) who pointed out that early reproduction in maize is highly phasic, with each phase showing susceptibility to water deficits. Thus, the higher the rainfall amount, the higher is the seed weight on one hand, and the more evident is the soil nutrient and water use efficiency of different varieties in the development of their seeds or grains.

Table 3: The Effect of Rainfall and Soil Nutrient on the 100-seed Weight of QPM Varieties in Zaria and Kano in 2008, 2009 and Combined

TREATMENT	Samaru	Kadawa	Samaru	Kadawa	Samaru	Kadawa
Varieties	**2008**		**2009**		**Combined**	
CM 2007 POOL Y QPM	**22.31ab**	**13.39**	**24.87ab**	**17.85**	**23.59ab**	**15.62**
POP/91 SUWAN-1-SRC	**17.79ab**	**11.84**	**9.76c**	**14.78**	**18.78c**	**13.31**
SAMMAZ 14	**25.15ab**	**12.60**	**27.94ab**	**16.80**	**26.55a**	**14.70**
FLINT Q	**22.10b**	**13.95**	**24.56b**	**18.55**	**23.33b**	**16.25**
DENT Q	**25.64a**	**10.85**	**28.48a**	**14.46**	**27.06a**	**12.66**
SAMMAZ 17	**24.86ab**	**11.78**	**27.51ab**	**15.47**	**26.19a**	**13.76**
Mean	**22.97**	**12.40**	**25.52**	**16.37**	**24.25**	**14.39**
SE±	**0.58**	**0.54**	**0.65**	**0.73**		
Significance	*	**NS**	*	**NS**	*	**NS**

Means followed by the same letter(s) within each column are not significantly different at 5% significant level using Duncan's Multiple Range Test. **NS: Not significant * Significant**

The effect of rainfall and soil nutrient on crop yield is presented on Table 4. With the same amount of rainfall as Table 2, a significant difference was observed among the varieties in each of the two stations. In Samaru where there is a much higher annual rainfall, only variety DENT Q was observed to produce a statistically different result. In Kadawa, only variety DENT Q and SAMMAZ 17 were observed to produce a statistically different result. FLINT Q produced the highest crop yield but varieties CM 2007 POOL Y QPM , POP 66 SR/ ACR-91 SUWAN-1-SRC$_1$/ ACR 91 SUWAN-1-SRC, SAMMAZ 14 were observed to be statistically similar it. The mean derived from all the varieties was higher in Zaria. In fact, Kadawa was only 48.5 % of Zaria.

In both stations, a much higher crop yield was observed in 2009 compared to 2008. This could be attributed to a higher annual rainfall in 2009 (177.5mm higher than 2008). Crop yield for 2008 was less than 80% of the yield in 2009 in Samaru, it was 79% of 2009 at Kadawa. This shows how vital rainfall is to crop yield. This supports Jaliya *et al*. (2008) and FAO (2010). The mean derived from all the varieties was higher in Zaria in both years. In fact, Kadawa was only 55.2% of Zaria in 2009.

From the combined analysis, a significant crop yield was observed in both stations. The mean crop yield for Kadawa was observed to be 52% of Samaru. A study carried out by Olaniran and Babatolu (1987) at Kabba, Nigeria, confirmed that pre-sowing rainfall is significantly correlated with the yields of sorghum and maize respectively supports this also. Based on the results obtained, QPM varieties were observed to have a very good photosynthetic capacity, soil use and WUE. These are closely related to rainfall amount. In fact, at Kadawa with a much lesser rainfall amount, no significant difference in crop yield was observed in the performances of these varieties except in the combined analysis. This and results from Samaru proves the superiority of some varieties over others.

Table 4: The Effect of Rainfall and Soil Nutrient on the Crop Yield of QPM Varieties in Zaria and Kano in 2008, 2009 and Combined

TREATMENT	Samaru	Kadawa	Samaru	Kadawa	Samaru	Kadawa
Varieties	**2008**		**2009**		**Combined**	
CM 2007 POOL Y QPM	**4.45a**	**2.60ab**	**4.88a**	**3.23ab**	**4.66a**	**2.92ab**
POP/91 SUWAN-1-SRC	**4.48a**	**2.40ab**	**4.90a**	**3.00ab**	**4.69a**	**2.70ab**
SAMMAZ 14	**4.91a**	**1.57ab**	**5.38a**	**1.95ab**	**5.15a**	**1.76bc**
FLINT Q	**4.33a**	**3.13a**	**4.75a**	**3.90a**	**4.54a**	**3.52a**
DENT Q	**1.49b**	**0.88b**	**1.55b**	**1.07b**	**1.48b**	**0.98c**
SAMMAZ 17	**5.05a**	**1.33b**	**5.57a**	**1.60b**	**5.31a**	**1.47c**
Mean	**4.10**	**1.99**	**4.50**	**2.46**	**4.30**	**2.23**
SE±	**0.19**	**0.30**	**0.22**	**0.37**		
Significance	*	*	*	*	*	*

Means followed by the same letter(s) within each column are not significantly different at 5% significant level using Duncan's Multiple Range Test **NS: Not significant * Significant**

Table 5 shows that at Kadawa, there was a significant and positive correlation between dry matter weight and 100-seed weight on the one hand and between 100-seed weight and crop yield on the other. It was not surprising to see a significant and positive correlation between crop stand count at 3WAS and crop yield on one hand and a highly significant and positive correlation between stand count at harvest and crop yield. However, that is not an objective of this paper.

Table 5: Correlation Coefficient between Crop and Vegetative Yield in Kadawa in 2008 and 2009 Wet Seasons Combined

	V6	**V12**	**V18**	**V19**	**V21**	**V24**	**V26**	**V28**
V6								
V12	**0.68****							
V18	**0.68****	**0.96****						
V19	**-0.09**	**- 0.40***	**-0.40***					
V21	**-0.08**	**- 0.39***	**-0.39***	**0.99****				
V24	**0.14**	**0.05**	**0.07**	**0.06**	**0.07**			
V26	**0.03**	**- 0.03**	**- 0.03**	**0.06**	**0.10**	**0.39***		
V28	**0.15**	**-0.06**	**- 0.08**	**0.59***	**0.60****	**0.16**	**0.46***	

V6 **Plant height at 12WAS**
V12 **Leaf area at 12WAS**
V18 **Leaf area at 12WAS**
V19 **Crop stand count at 3WAS**
V21 **Stand count at harvest**
V24 **Dry matter weight**
V26 **100-seed weight**
V28 **crop yield**
***Significant and positively correlated **Highly significant and positively correlated**

Table 6 shows that at Samaru, there was no correlation between dry matter weight and 100-seed weight on one hand and in fact, a negative correction between 100-seed weight and crop yield on the other hand.

Table 6: Correlation Coefficient between Crop and Vegetative Yield in Samaru in 2008 and 2009 Wet Seasons Combined

	V5	V11	V17	V20	V22	V23	V25	V27
V5								
V11	0.61*							
V17	0.70*	0.44*						
V20	-0.12	-0.12	0.26					
V22	-0.12	-0.12	0.26	0.10**				
V23	-0.26	0.04	-0.12	0.36*	0.36*			
V25	0.20	0.40*	-0.20	-0.46*	-0.46*	-0.10		
V27	-0.04	-0.07	0.13	0.85**	0.85**	0.15	-0.10	

V5 Plant height at 12WAS
V11 Leaf area at 12WAS
V17 Leaf area at 12WAS
V20 Crop stand count at 3WAS
V22 Stand count at harvest
V23 Dry matter weight
V25 100-seed weight
V27 crop yield
***Significant and positively correlated **Highly significant and positively correlated**

However, it is not surprising to see a highly significant and positive correlation between crop stand count at 3WAS on one hand and crop stand count at harvest on the other hand with crop yield.

CONCLUSION

In term of dry matter, varieties four and three in Samaru and Kadawa respectively produced the best results. Furthermore, Variety 6 (Sammaz 17) is the most recommended in terms of crop yield in Zaria while it is variety four (Flint) for Kano. Correlation analysis showed that in Kadawa, dry matter weight and crop yield were significantly and positively correlated while in Zaria, the results were different such that there was no positive correlation between dry matter and 100-seed weight and crop yield. These results cannot be unconnected to ecology as Zaria and Kadawa fall under different environmental conditions like rainfall and temperature. It is recommended therefore that these and more QPM varieties be evaluated in other parts of the country. Secondly, the relationship between rainfall amount, soil, water use efficiency (WUE) and photosynthetic capacity of QPM varieties should be further examined. Finally, positive correlation was observed between dry matter weight, 100-seed and crop yield at Kadawa while the result was the opposite in Zaria.

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