Evaluation of Varietal and Moisture content Effect on Angle of Repose and 1000 Grain Weight of Cowpea Variety (Vigna Unguiculata (L) Walp)

Adegbulugbe, Thomas A.

Federal College of Agriculture, Institute of Agricultural Research & Training, Agricultural Engineering Department,

P. M. B. 5029 Ibadan, Nigeria

Email:thomasadegbulugbe@yahoo.com

Olujimi, Olugbemi A.

TNS RMS, Data Processing Department,

26, Odozi Street, Ojodu, P. O. Box 8225, Ikeja, Post Code (100001) Lagos Nigeria

Email: oolujimi@rms-africa.com olugbemijimi@yahoo.com

Abstract

Cowpea, known to be major source of plant protein in developing countries and consumed in various form by both animal and human. This makes it one of the essential crop in Sub-Sahara African countries, therefore in designing and construction of processing machine for this crop like harvester, thresher, etc, it is very important to know the effect of moisture content and genotypic composition of this crop on some of its essential engineering properties, for example its Angle of Repose and 1000 Grain Weight. For this study, TVX 3236, Ife Brown and IT81D-994 Cowpea varieties and moisture content ranges from 10 to 35 per cent wet basis were selected. From the result of the regression analysis, it was found out that Angle of Repose of cowpea variety increases with increase in moisture content in a non-linear relationship with coefficient of determination (r^2) being 0.927, 0.996 and 0.892 for TVX 3236, Ife Brown and IT81D-994 respectively. Here, Duncan Multiple Range Test (Duncan's Test) at $P < 0.05$ shows that TVX 3236 produced the highest varietal effect on Angle of Repose while the least varietal effect on Angle of Repose is from Ife Brown.

Similar phenomenon was found in the effect of moisture content on 1000 Grain weight. It

was found through a non-linear regression relationship that an increase in moisture content leads to increase in 1000 Grain weight (r^2=0.967, 0.999 and 0.995) for TVX 3236, Ife Brown and IT81D-994 respectively. Duncan's Test at $P < 0.05$ here shows that IT81D-994 produced the highest 1000 Grain weight while the least 1000 Grain weight was observed on TVX 3236.

Duncan's Test carried out on the effect on moisture content on both Angle of Repose and 1000 Grain weight shows that 35% moisture content wet basis produced the highest moisture content effect on both engineering (physical) properties.

Introduction

Cowpea (*Vigna Unguiculata (L) Walp*), a protein-rich warmth loving herbaceous, a pod bearing annual plant, cultivated in many parts of the tropical and sub-tropical world. It is the major source of plant protein in developing countries of the world and this plant is called beans in Nigeria.

Cowpea is believed to be a native of West Africa though the annual world cowpea production in 1996 was estimated at 3 million tonnes out of which Nigeria contributes 1.7 million tonnes (Singh *et al*, 1997). Furthermore, many varieties of cowpea have been developed in Nigeria by Agricultural research institution.

As a result of the importance of this crop in sub-Saharan African countries, it is very essential to determine the effect of moisture content and genotypic factor of this crop on some of its physical properties which is very important in designing and construction of processing machines for this crop like thresher, dryer, harvester etc. In this study, Angle of Repose and 1000 Grain weight were studied on.

Angle of repose is the angle of which a bulk sample of the materials makes with the horizontal at rest. This is very useful in designing of grain hoppers, conveyors, spouts and grain outlet of handling machinery and equipment.

As the phrase is, 1000 Grain Weight is the weight of the 1000 randomly selected cowpea grains. This is important in estimating the quantity, pressure on bins, and designing for strength and size of materials to utilize for construction.

Material and Methods

Materials

The cowpea seeds used for this study consist of three cowpea varieties obtained from the International Institute of Tropic Agriculture (I.I.T.A.) and Institute of Agricultural Research and Training (I.A.R.&T.) both in Ibadan. These cowpea varieties are: TVX3236 (a small size seed), Ife Brown (a medium size seed), and IT81D – 994 (a large size seed). These materials were chosen because they are locally bred varieties released for farmers' used from about the last three decades after having performed well during the multi-location field trials with other varieties.

Methods

Series of experiments were carried out to determine the effect of moisture content on the physical properties of these varieties. Different moisture levels were selected as the bases of our study, these are: 15, 20, 25, 30, 35 and 40 per cent wet basis.

Effect of Moisture Content on Angle of Repose

Samples of the three cowpea varieties were conditioned to six moisture levels, (15, 20, 25, 30, 35 and 40 per cent wet basis), put in black polythene bags which were then well seated and kept in fridge at 5^{o}C for two weeks.

For determining the angle of repose, each sample was brought out, allowed to warm up to the room temperature and poured into the angle of repose box until such is filled. Then the front panel was removed, allowing the grain to flow to natural rest position, and the angle of repose determined by measuring the height H and the perpendicular distance to the outer most seeds.

The angle of repose

$$\Theta = \tan^{-1}\left(\frac{H}{K}\right)$$

For each moisture content level, this was replicated five times and the average recorded. The whole experimental set up was designed in a 3 X 6 Factorial Completely Randomised Design making a total of 90 observations.

Effect of Moisture Content on 1000-Grain Weight

Samples of conditioned grains were thoroughly mixed together and one thousand grains were taken by hand picking and counting every sixth seed. The one thousand grain were then weighed and this was replicated five times and the average recorded. The measurements were carried out for five moisture levels (15, 20, 25, 30 and 35 per cent wet basis). Here, a 3 X 5 Factorial in Completely Randomised Design make up the experimental set-up making a total of 75 observations.

Result & Discussion

Relationship between Angle of Repose and Moisture Content

The experimental result for angle of repose with respect to moisture content for the three cowpea varieties, are shown in figures 1.1, 1.2 and 1.3.

In the moisture range of 10 to 35 per cent wet basis, the angle of repose was observed to increase with increase in moisture content as follows:

TVX 3236: 20.8 to 29.6 degrees

Ife Brown: 19.6 to 28.9 degrees

IT81D-994: 21.3 to 28.3 degrees

The experimental values of the angle of repose for the three varieties were found to bear the following polynomial relationship with moisture content:

TVX 3236: $\Theta = 14.57 + 0.774Mc - 0.01Mc^2$ $(r^2 = 0.927)$

Ife Brown: $\Theta = 17.44 + 0.285Mc - 0.0008Mc^2$ $(r^2 = 0.996)$

IT81D-994: $\Theta = 19.06 + 0.293Mc - 0.002Mc^2$ $(r^2 = 0.892)$

Where Θ is the angle of repose of the cowpea and Mc = Per cent Moisture content

The values obtained from this study bear a non-linear relationship with moisture content. Gupta and Das (1997), Visvanathan *et al* (1996) and Suthar and Das (1996) reported linear relationship between angle of repose and moisture content for sunflower, neem nut and Karingda seeds, while some other investigators such as Dutta *el al* (1988) and Shepherd and Bhardwaj (1986), reported non-linear relationship for gram and pigeon pea respectively.

Varietal, Moisture Content and their Interaction Effect on Angle of Repose

The analysis of variance carried out on angle of repose in testing for the varietal, moisture content and the interaction effect of these two factors on angle of repose shows that, varietal effect of the varieties used for this study was significantly different on the angle of repose. Duncan multiple range test further shows that TVX 3236 produced the highest angle of repose, this was followed by IT81D-994 but the variety that produced the least angle of repose was Ife Brown (Table 1.1). Several reasons might have suggested this significant different in varietal effect on angle of repose, this includes the following: firstly, Ife Brown that produce the least angle of repose may have the smoothest skin coat while TVX 3236 has the roughest skin coat, making it easier for former's seed to be able to roll and slide more easily against one another. Secondly, there might have been some hereditary (genotypic) factors making the angle of repose different in the three varieties. Also for the effect of moisture content on the angle of repose, it was discovered through the analysis of variance that this effect was significantly different. Each moisture level (content) produced different effect on the angle of repose of these cowpea. It was found out that the higher the moisture content, the higher the angle of repose that any of these cowpea will produce. With respect to this, cowpea variety at 35% moisture content produce the highest angle of repose but the least angle of repose was produced by cowpea varieties with 15% moisture content (Table 1.2)

On the interaction effect of variety and moisture content on angle of repose, analysis of variance shows a significant different here (Table 1.3). TVX 3236 at either 30% and 35% moisture contents produce the highest angle of repose while Ife Brown at 10% moisture content produce the least angle of repose.

Relationship between 1000 Grain Weight and Moisture Content

The effect of moisture content on one thousand –grain weight were shown in figures 1.4, 1.5 and 1.6 for the three varieties. The one thousand grain weight ranges from 94.19 to 131.53g;

142.08 to 232.60g and 182.42 to 236.46g for TVX 3236, Ife Brown and IT81D-994 respectively.

The one thousand grain weight as expected increases with increase in moisture content, but the relationship of the experimentally obtained values was non-linear.

Visvanathan *et al* (1996) and Dutta *et al* (1988) reported linear relationship for neem nut and gram thousand-grain weight with correlation coefficient of .99.

Theoretically, the thousand grain mass should exhibit the following relationship with moisture content:

$m1000 = \bar{m}_{1000}(1+M)$

(where M is moisture content, % dry basis, and $\bar{m}_{1000}$ is mass of dry matter in one thousand seed)

Whereas, the observed relationship is polynomial as follows:

TVX 3236: $W_{1000} = 99.431 - 0.904Mc + 0.050Mc^2$ $(r^2 = 0.967)$

Ife Brown: $W_{1000} = 135.39 - 0.15Mc + 0.083Mc^2$ $(r^2 = 0.999)$

IT81D-994: $W_{1000} = 185.72 – 1.082Mc + 0.073Mc^2$ $(r^2 = 0.995)$

(W_{1000} is the one thousand grain weight and Mc is the per cent moisture content wet basis)

Varietal, Moisture Content and their Interaction Effect on 1000 Grain Weight

For 1000 grain weight among the varieties, the result of the analysis of variance shows that there is significant difference in the contributing effect of each variety to their corresponding 1000 grain weight. That is, varietal effect on the 1000 grain weight of cowpea was significantly different. This implies that each variety has a peculiar contribution to the 1000 grain weight different from others, with IT81D-994 showing the highest 1000 grain weight, followed by Ife Brown, but the least among them is TVX 3236 (Table 1.1)

Among the various moisture levels, analysis of variance also shows that there is significant difference in the effect of each moisture level on the 1000 grain weight. Here, Duncan's test shows that the highest moisture level (35% moisture content) produced the heist 1000 grain

weight with mean (200.197g) but the least moisture level (10%) produced the least 1000 grain weight (139.68). Hence, we see that within the range of moisture content studied, the higher the moisture level, the higher the 1000 grain weight (Table 1.2)

On the interaction effects of the varieties and moisture levels, it was discovered that this interaction effect on 1000-grain weight was significantly different. The 35% moisture level against varieties Ife Brown and IT81D-994 produced the highest 1000-grain weight which are not significantly different from each other. But TVX 3236 at 10% moisture level produced the least 1000-grain weight (Table 1.3).

Conclusion

As we can see from the result and discussion, it was found out that there is significant different in both varietal and moisture content effects of these cowpea varieties on their angle of repose and 1000 grain weight. Furthermore, to help the agricultural engineers in designing and fabricating cowpea processing machineries like harvester, thresher, screener, we have used tools of statistical techniques to evaluate the effect of these factors (varietal and moisture content) on engineering properties of these cowpea varieties studied and this had revealed a lot of important hidden properties of these varieties which are essential before fabricating any of their processing machineries.

Table: 1.1 Means for the Varietal Effect on Angle of Repose and 1000 Grain Weight

Variety	Angle of Repose (Degree)	1000 Grain Weight (g)
TVX 3236	26.149a	108.153c
Ife Brown	24.317c	180.143b
IT81D-994	24.75b	203.809a
S.E.	0.146	0.867

Note: Along the same column, means with different alphabets are significantly different ($P < 0.05$)

S.E.= Standard Error of the Treatment Means

Table: 1.2 Means for Moisture Content Effect on Angle of Repose and 1000 Grain Weight

Moisture Content (%)	**Angle of Repose (Degree)**	**1000 Grain Weight (g)**
10	21.569f	193.675f
15	22.154e	145.30e
20	24.749d	153.575d
25	26.441c	165.972c
30	27.265b	179.491b
35	28.257a	200.198a
S.E.	0.206	1.227

Table: 1.3 Means for the Interaction Between Varieties and Moisture ContentEffect on Angle of Repose and 1000 Grain Weight

Variety	**Moisture Content (%)**	**Angle of Repose**	**1000 Grain Weight**
TVX 3236	10	21.912g	94.192m
TVX 3236	15	22.39g	98.078lm
TVX 3236	20	27.04cd	103.692kl
TVX 3236	25	27.558bc	108.028jk
TVX 3236	30	28.806a	113.398j
TVX 3236	35	29.188a	131.532i
Ife Brown	10	20.38h	142.08h
Ife Brown	15	21.81g	151.72g
Ife Brown	20	23.506f	166.06f
Ife Brown	25	25.304e	184.24e
Ife Brown	30	26.372d	204.16c
Ife Brown	35	28.53ab	232.6a
IT81D-994	10	22.414g	182.754e
IT81D-994	15	22.262g	186.106de
IT81D-994	20	23.702f	190.972d
IT81D-994	25	26.46cd	205.648c
IT81D-994	30	26.618cd	220.916b
IT81D-994	35	27.054cd	236.46a
	S.E.	0.356	2.124

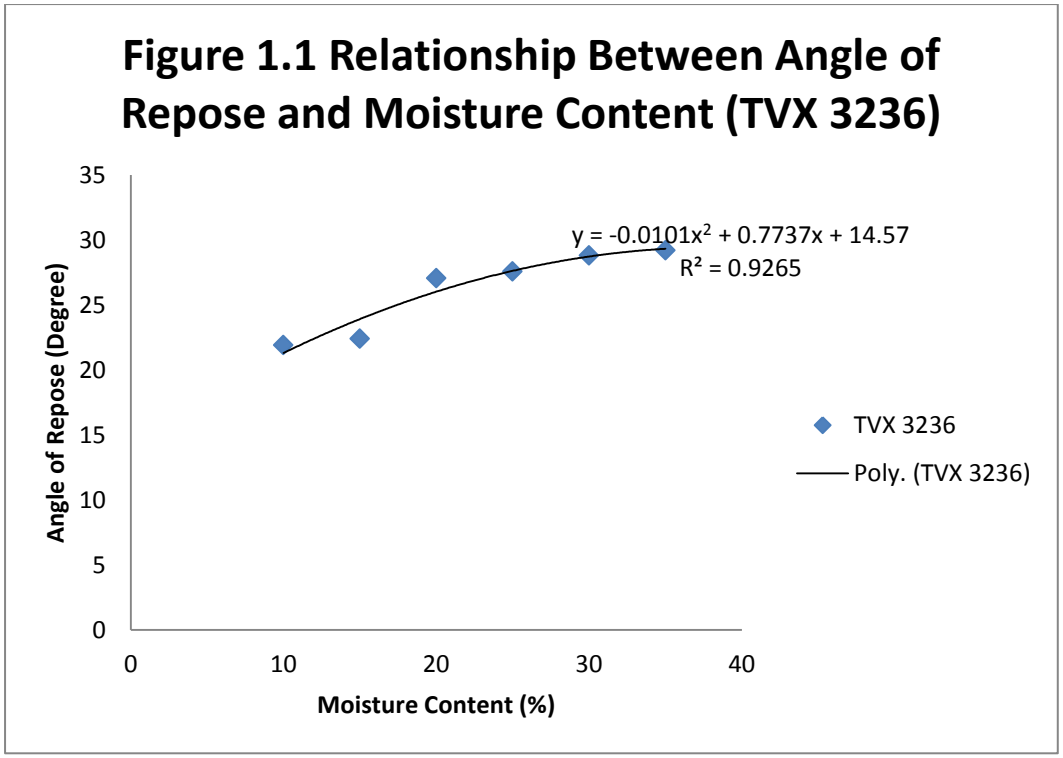
Figure 1.1 Relationship Between Angle of Repose and Moisture Content (TVX 3236)
y = -0.0101x² + 0.7737x + 14.57
R² = 0.9265
Angle of Repose (Degree)
Moisture Content (%)
TVX 3236
Poly. (TVX 3236)
0
5
10
15
20
25
30
35
0
10
20
30
40

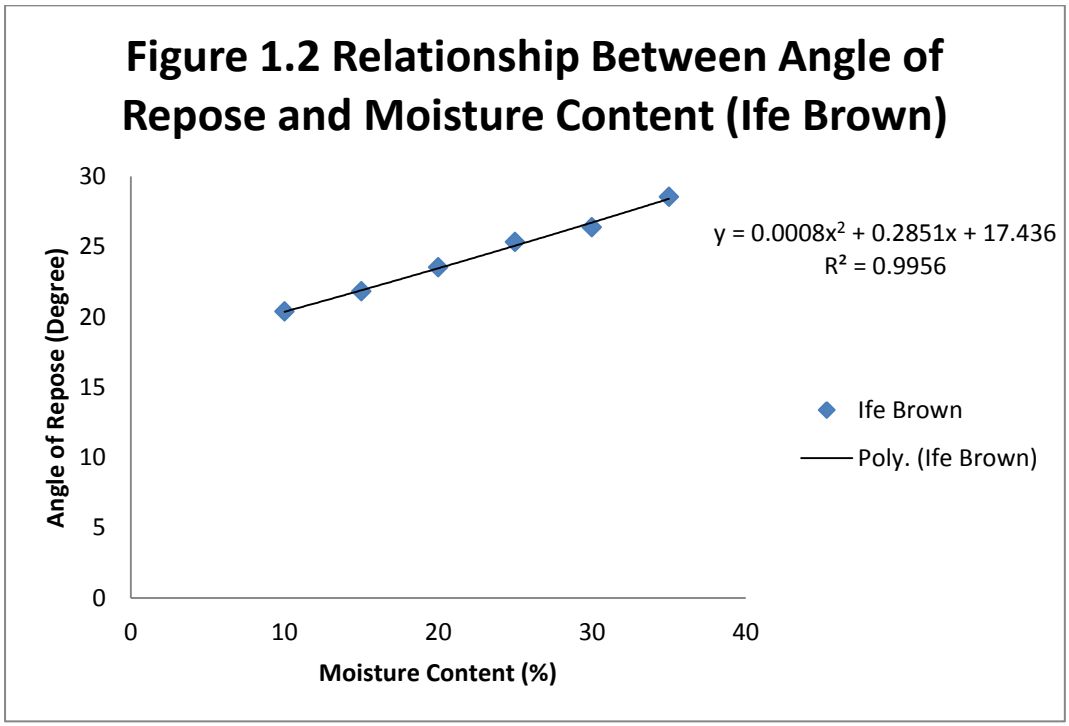
Figure 1.2 Relationship Between Angle of Repose and Moisture Content (Ife Brown)
y = 0.0008x² + 0.2851x + 17.436
R² = 0.9956
Angle of Repose (Degree)
Moisture Content (%)
Ife Brown
Poly. (Ife Brown)
0
5
10
15
20
25
30
0
10
20
30
40

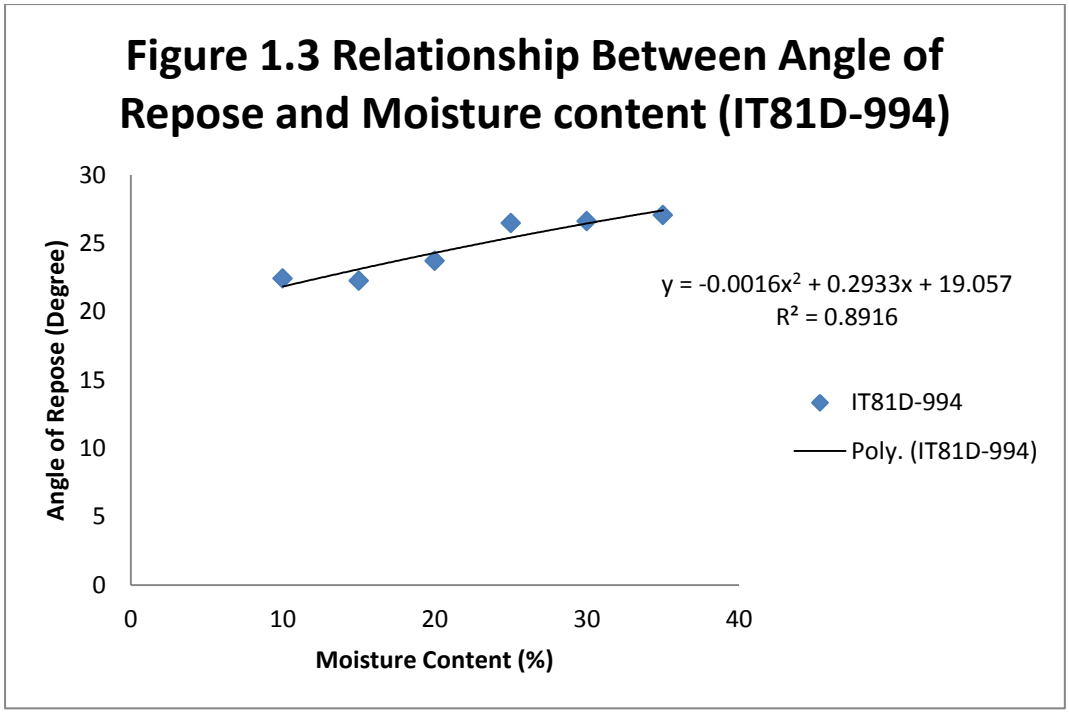
Figure 1.3 Relationship Between Angle of Repose and Moisture content (IT81D-994)
Angle of Repose (Degree)
30
25
20
15
10
5
0
0
10
20
30
40
Moisture Content (%)
y = -0.0016x² + 0.2933x + 19.057
R² = 0.8916
IT81D-994
Poly. (IT81D-994)

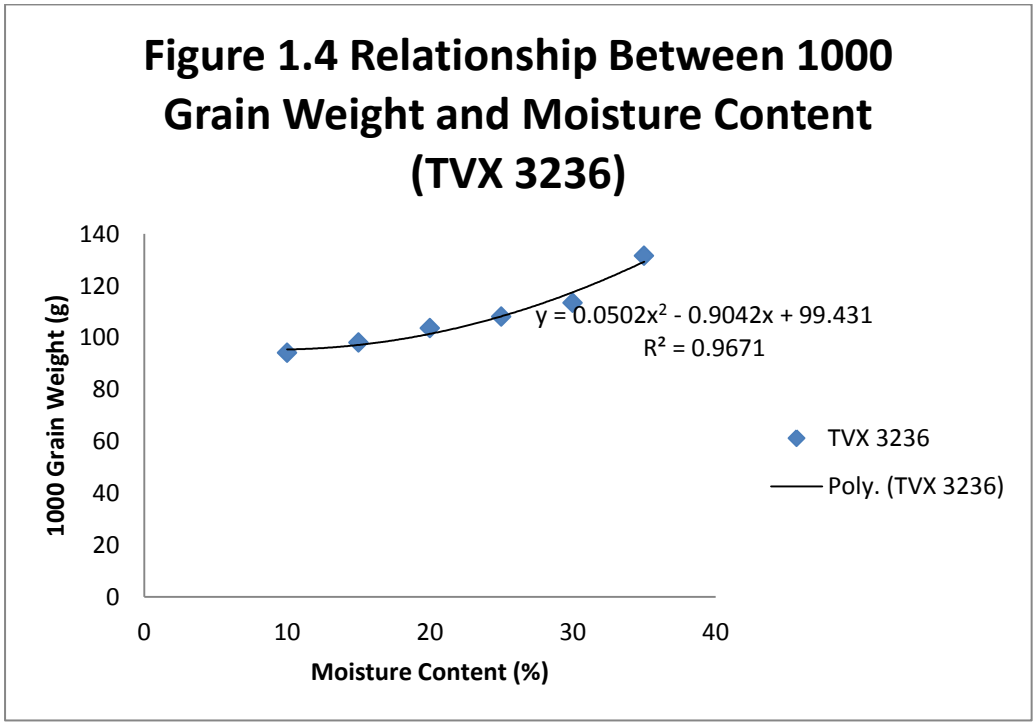
Figure 1.4 Relationship Between 1000 Grain Weight and Moisture Content (TVX 3236)
1000 Grain Weight (g)
140
120
100
80
60
40
20
0
0
10
20
30
40
Moisture Content (%)
y = 0.0502x² - 0.9042x + 99.431
R² = 0.9671
TVX 3236
Poly. (TVX 3236)

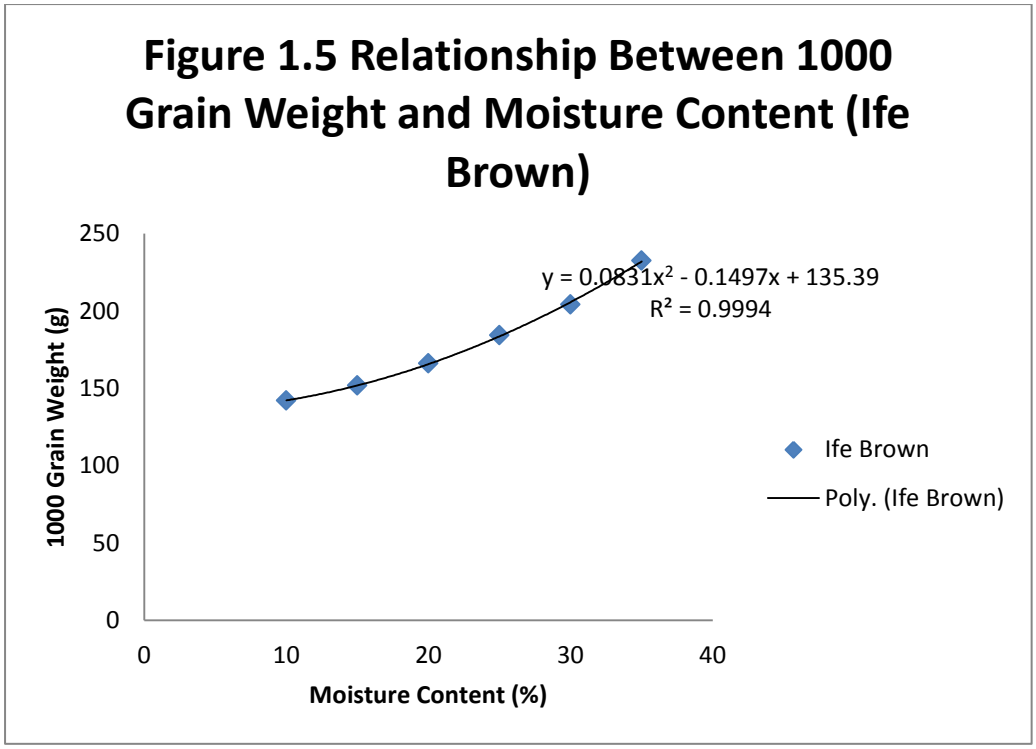
Figure 1.5 Relationship Between 1000 Grain Weight and Moisture Content (Ife Brown)
y = 0.0831x² - 0.1497x + 135.39
R² = 0.9994
1000 Grain Weight (g)
250
200
150
100
50
0
0
10
20
30
40
Moisture Content (%)
Ife Brown
Poly. (Ife Brown)

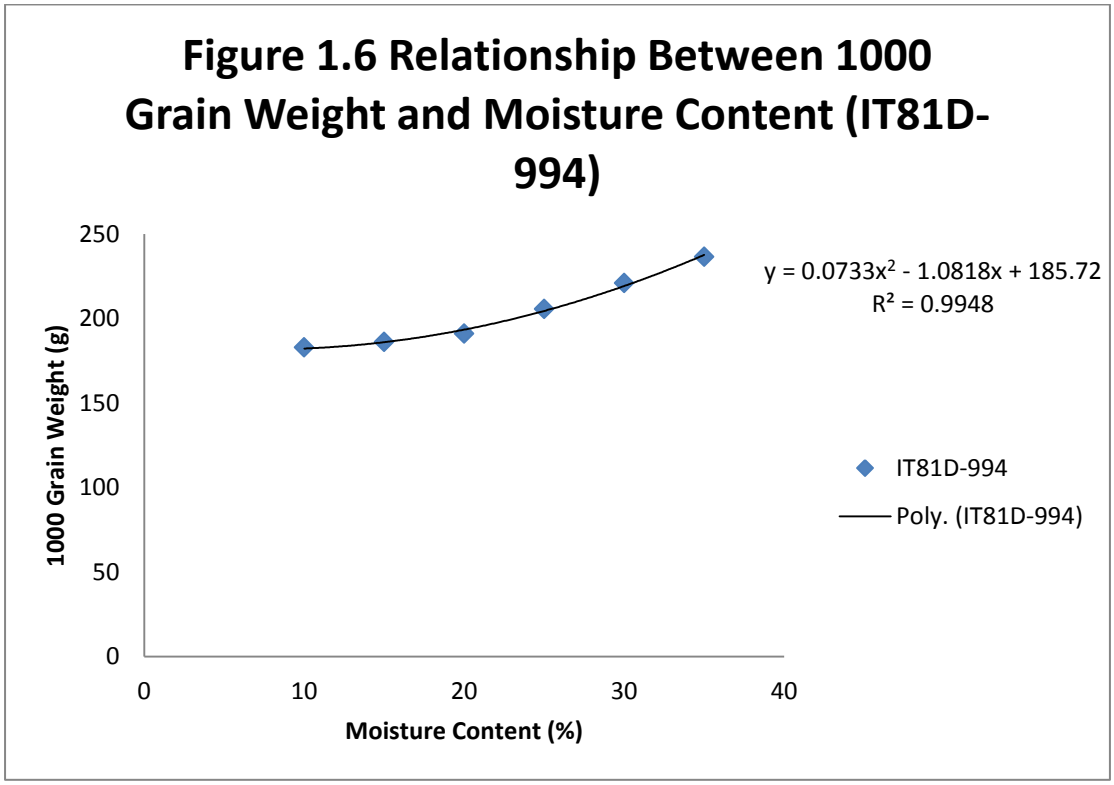
Figure 1.6 Relationship Between 1000 Grain Weight and Moisture Content (IT81D-994)
y = 0.0733x² - 1.0818x + 185.72
R² = 0.9948
1000 Grain Weight (g)
250
200
150
100
50
0
0
10
20
30
40
Moisture Content (%)
IT81D-994
Poly. (IT81D-994)

REFERENCES (RÉFERENCES)

1. Dutta S. K., Nema V.K. and R. K. Bhardwaj 1988. Physical Properties of Gram. *Journal of Agricultural Engineering Research*. 39:259-268.
2. Gupta, R. K. and S. K. Das (1987); Physical Properties of Sunflowers Seeds. *Journal of Engineering Research,* 66 (1); 1-8
3. Shepherd H. and Bhardwaj. 1986. Moisture Dependent Physical Properties of Pigeon Pea. *Journal of Agricultural Engineering Research*, 35:227-234, 1986
4. Suthar, S. H. and Das, S. K. 1996. Some Physical Properties of Karingda *[Citrullus lanatus (Thumb) Mansf seeds]*. *Journal of Agric. Engineerin*g
5. Singh B. B., Chambiss, O. L. and Sharma 1997. Recent Advances in Cowpea. Breeding Advances in Cowpea Research (eds). B. B. Singh, D. R. Moham, K.S. Dashiell and L. E. N. Jackal. Co-publication of IITA and Japan International Research Centre for Agric Sciences (JIRCAS) IITA, Ibadan, Nigeria. 30 – 49
6. Visvanathan, T.; Palanisamy, P. T. Gothandapani, L. and V. Screenarayanan. (1996) Physical Properties of Neem Nut. *Journal of Agricultural Engineering Research* 63:19-26

RÉSUMÉ (ABSTRACT)

Cowpea est connu comme la principale source de protéines végétales dans les pays développés et est consommée aussi bien par les hommes que les animaux. Ceci fait d'elle l'une des cultures essentielles en Afrique sub-saharienne, et donc dans la conception et la construction des machines de traitement pour cette culture comme les moissonneuses, les batteuses, etc.

Il est très important de connaitre l'effet de l'humidité et la composition génotypique de cette culture sur quelques unes de ses propretés physiques, par exemple son « Angle de repos » et la graine de poids 1000. Pour cette étude, TVX 3236, Ife Brown et IT81D-994 Variétés de Cowpea et l'humidité de 10 à 35 pour cent ont été sélectionnés. D'après les résultats de l'analyse de la régression, il a été découvert que l'« Angle de repos » des variétés de Cowpea augmente avec la hausse de la teneur en humidité dans une relation non linéaire et le coefficient de détermination (r^2) étant de 0.927, 0.996 et 0.892 pour TVX 3236, Ife Brown et IT81D-994 respectivement. Ici, le test sur les multiples groupes (test de Duncan) montre que

TVX 3236 a produit le plus grand effet variétal sur Angle de repos » tandis que le plus petit effet a été observé sur Angle de repos » d'après Ife Brown.

Un phénomène similaire a été découvert dans l'effet de la teneur en humidité sur les graines de poids 1000.Il a été découvert à travers une régression non linéaire qu'une augmentation de la teneur en humidité conduit à l'augmentation des graines de poids 1000 (r^2=0.967, 0.999 et 0.995) pour TVX 3236, Ife Brown et IT81D-994 respectivement. Le test de Duncan $P<0.005$ ici montre que IT81D-994 a produit la plus grande graine de poids 1000 tandis que la moindre graine de poids 1000 a été absorbée sur TVX 3236.

Le test de Duncan effectue sur l'effet de la teneur en humidité simultanément sur l'« Angle deRepos » et la graine de poids 1000 montre que 35% de la teneur en humidité a produit l'effet de la teneur en humidité le plus élevé sur les 2 propriétés physiques.