APPROPRIATE MANAGEMENT AND OPERATIONAL PLANNING TECHNIQUE FOR MECHANIZED SOYBEAN AND MAIZE PRODUCTION IN NIGERIA

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Abstract

There is high demand for Soybean both for industrial and domestic usage in Nigeria and international food industries. The climate and soil conditions of most of the Nigeria's farmland, except the extreme northern part of the country are favourable for mechanized rain-fed soybean production. The result of the study carried out at Bacita, middle belt of Nigeria shows that mechanized soybean and maize production project was found to be viable. Over 45% profit before tax was obtainable with good system management and operational efficiency when planted in rotation with maize under a good farm management condition.

Keywords: Appropriate, Mechanization, Rain-fed, Soybean, Operational efficiency.

Introduction

The present Nigerian Government policies of poverty alleviation and job security for agricultural sector, favour food production industries and all effort must be made to make sure that the farm inputs and spare parts reached the farmer at reasonable time and at affordable price. Soybean produces highest yield of protein per unit area of land compared to any plant or animal food source that also produces calories. It is considered as an industrial crop and as well used directly for human food which can be processed even at the village level in the rural areas. The crop grows well and can survive where moisture is too much for survival of groundnut (Ashaye et al., 1984).

Establishment of Environmental and Commercial Parameters

There is need for establishment of environmental and commercial parameters within which soybean must be produced along with maize. The best soybean yields are obtainable in well- drained sandy loam to clay loam soils on a fairly flat land with pH between 6 and 7 that can also support crops like sorghum and maize that are highly sensitive to water logging (AMREC, 2010). The rainfall requirement between 500-750 mm is adequate for high soybean seed yield and water is very important at flowering and bud forming into pod stages (Weiss, 1983). Climatic suitability for soybean production is where there is 20-35^{o}C day temperature with daily mean of 30-32^{o}C that must vary with life of plant day and night which is more significant during flowering stage as reported by RMRDC (2004). High humidity during seed maturation will lower viability and seed vigour which will reduce seed storage life, Weiss (1983). Soybean is highly photoperiodic because a variation of 15 minutes in day length may inhibit flowering of some varieties. The interaction between day length and night temperature with the time of first flowering on soybean is very important to consider in selecting the seed variety (Weiss, 1983). Soybean is usually grown in Benue province or environ, Abuja area, Southern Kaduna, Nasarawa or generally middle belt to some part of South East and South West of Nigeria where average yield of about 2,000 kg/ha can now be obtained (IITA, 1988). The highest Soybean export from Nigeria in 1964 was 26,450 tons from about 32,000ha, and the market then was UK, Italy, Hungary and W Germany as reported by Ashaye et al (1984). Today the international sale market outlets are far more.

The primary uses of soybean in Nigeria are as source of protein supplement in diet. It contains more digestible nutrient percentage than cowpea. It is now becoming more popular in many Nigeria home, with new discoveries of better way to prepare it as palatable food without changing colour.

Most of what was produced has been for export as cash crop until recently when much is used for livestock and baby food production (Glycinel, 1986) and (IITA., 1986)

But for now and future, with the present high rate of industrial development and use of soybean and its products, the commercial production of soybean is a very viable project in Nigeria. To meet the high industrial and domestic demand for soybean as raw material for human food, livestock feed and chemical industrial processes, there is need to increase labour and machinery productivity of soybean. The only solution to this will be to mechanize soybean production at both commercial and small scale levels. It is worth of note that better knowledge of the past and present equipment selection and utilization is a key component for the improvement of the planning process that will impact modern production technology to agricultural sector in the years to come (Andrade and Jenkins, 2003).

There was need to find solution to refertilize the over-used large farm land being used to cultivate sugar cane only for more than 20 years. The study took place on sugar cane out grower farmland that was located in the well drained upland soil of Bacita sugar cane plantation, Kwara State, Nigeria. After much agricultural experts' consultations, it was agreed that cultivation of soybean on the land for some years can refertilize the soil which then brought about this project study.

Methodology

Production Planning and Control

Planning objectives: The objectives of this production planning exercise were to plan the mechanized soybean production on a 150 ha of upland at Bacita with a well-drained soil at Southern Guinea Savannah grassland vegetation in Nigeria. The target yield was 2000 kg/ha for large scale soybean production. The cropping was in rotation with maize in this location. The crops average temperature, relative humidity, sun shine hours and rainfall within the period cultivation was determined from agronomic requirement of these crops and confirmed suitable from what was collected at meteorological station at Bacita as shown in tables 1, 2, 3, and 4. The maize and soybean was cultivated on 75 ha each in every season. The tractor and machinery selected for the crop cultivation, crop establishment, weed control up to harvesting and transporting to the store matched each other in terms of row spacing and established tramline to reduce long time soil compaction problem (Adisa, 1987).

Planning constraints and variables

Planning constraints and variables were labour, machinery cost and duration of rainfall. Crop and operational sequencing were also considered here since the operations were overlapping with multi periods. Other limiting resources were fuel, spare parts, fertilizer and herbicide cost and availability (Kepner et al., (2005).

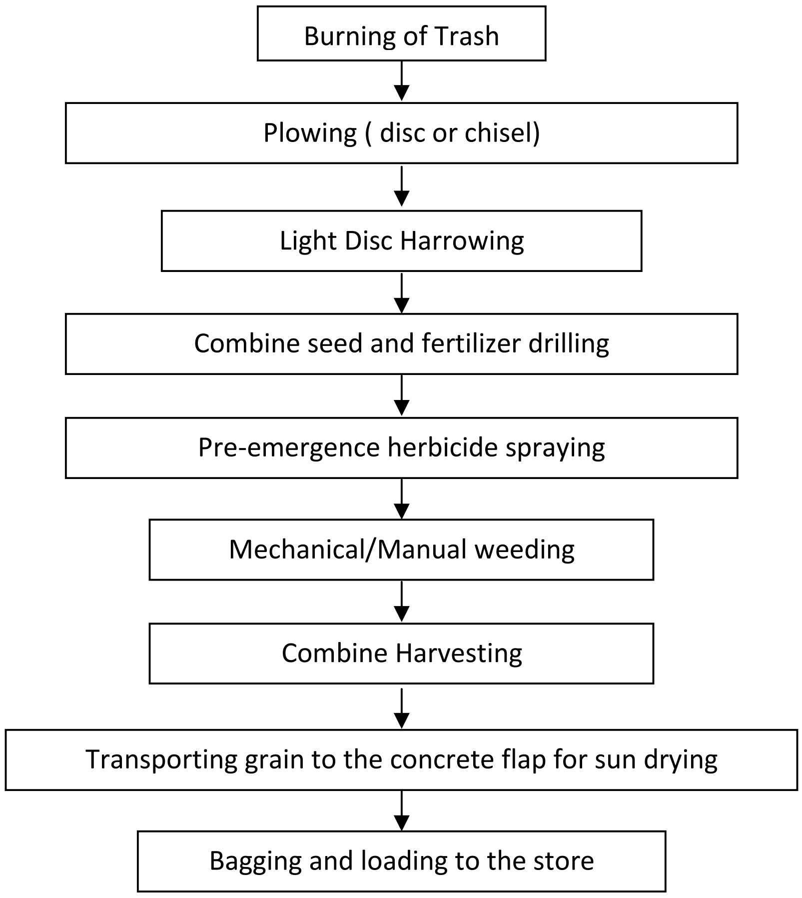
To overcome these constraints and variables the following was carried out:
Labour was available in abundance in the farm location and fairly cheap as well. Tractors and machinery were readily available with their spare parts in the nearby towns like Ilorin, Ibadan and Kaduna. The rainfall during the months of July, August and September were adequate for soybean and maize growth. The corresponding temperature, relative humidity, and sunshine hours during growing period and at the time of harvesting were ideal for soybean/maize production as earlier stated in section 1.2 under introduction.

Repair and Maintenance

The 150 ha farm size required efficient tractor and machinery repair and maintenance system, a mobile workshop for equipment maintenance. Meeting this requirement improved the operation efficiency of the system because there was less reliance on external services to take care of both daily and periodic maintenance and breakdowns. Ten percent of the total equipment cost was used to stock the fast moving spare parts (consumables) for the machinery and tractor (Kepner et al., 2005). This made repairing of minor breakdowns possible right on the field to reduce time lost. Major repairs and maintenance were carried out after closing time or before critical field operation (Deere, 1984). Fuel and oil were stored on the farm to enable filling of the machines possibly overnight. This was to reduce delay at the start of the day when machines were supposed to be working on the field.

Other Means to Improve Pre-field and In-field Efficiency

Tractor and machines routine maintenance and overhauling were done before the production season. There were means for communicating with sound transport provided between field and workshop for reporting any breakdown and its nature. There was proper record keeping of every tractor and machinery daily hours of work and out of work with reasons why it was out of work. This was used to calculate the tractor and machinery performance. The head land for turning was between 1½ and 2 times the length of tractor and implement to reduce turning time. And also the length of field was as long as possible, far more than the breadth to reduce time lost in turning. The size of the tractor selected matched the size of the implements. The tractor and machinery were operated with the full capacity (Deere 1984). Figure 1 is the required mechanized field operations.



aFigure 1: Mechanized field operations

Machinery Selection for the Farm

Time available was 7 hours per day and 5 days per week. The work was to be finished in 3 weeks. Therefore total time available was
5 x 7x 3 = 105 hours to cover 75 ha.

(a) Chisel plow size required
S x W x E = 75 ha
Capacity C = $\frac{SxWxE}{10} = \frac{75}{105} = 0.72 ha/h$
Where: Speed, S = 6km/h, implement width is W and field efficiency E = 60%
$\therefore W = \frac{Cx\ 10}{SxE} = \frac{0.72\ x10}{6\ x\ 0.6} = 1.97\ m = 2\ m$

A disc plow of 2 m width was selected and therefore total disc plow required was one disc plow of 2 m width. In the same way the following equipment was selected.

(b) Disc harrow required was one of 3m width.
(c) Combine seed fertilizer drill required was one of 2.5 m width.
(d) Sprayer required was one of 3 m width.
(e) Fertilizer broadcaster for maize required was one of 5 m width.
(f) Combine harvester required was one of 3 m width.
(g) Tractor trailer required was one of 4 tons.

Tractor power requirement

Soil type is firm clay loamy soil with specific soil resistance of 35 KN/m^2 for disc plow (from soil resistance table).

Disc plow depth = 0.2 m
Disc plow width = 2 m

Therefore, Tractor drawbar pull = 35 x 2 x 0.2 = 14 KN
The speed of plowing was 6 km/h

Drawbar power = $\frac{14x6}{3.6} = 23.3KN$

For firm soil, ratio of P.T.O power to usable drawbar power

$$\frac{1}{\text{ground drive efficiency (\%) x engine loading (\%)}}.$$

Ground drive efficiency was 67% and engine loading efficiency was 85% (obtained from engine characteristic table).

$= \frac{1}{0.67x0.85} = 1.8$

The actual Engine P.T.O power required = 23.3x1.8 = 42KW Tractor power rating of 45KW (60 hp) was recommended to take care of other losses.
Power required for all operations per hectare
Number of tractor required was two of 45KW
Therefore total tractor power required was 90KW
Total area of farm was 150ha (for soybean and maize).

Power per hectare = $\frac{90}{150} = 0.6KW / ha$

Whole Farm Budgeting

Enterprise	Gross margin ₦/ha	ha	Total ₦
Soybean	60,000 x 2	75	9,000,000
Maize	46,000 x 1.5	75	5,175,000
Total farm gross margin			14,175,000

Fixed Costs/year

Tractor, machinery mobile workshop depreciation	1,802,336
Grain store, concrete flap and workshop shed depreciation	213,040
Interest charges (12% assumed)	824,953
Taxes, shelter and insurance (5% assumed)	758,868
Regular labour	504,000
Total Fixed Costs/year	4,103,197

Variable Cost/year

Repair & maintenance of Tractor, machinery and building	729,045
Fuel cost for all operations	966,278
Oil and filter cost (20% of fuel cost)	247,461
Casual labour	280,000
Cost of chemical	980,000
Cost of seed materials	373,500
Cost of fertilizer	828,112
Cost of fast moving spare parts	323,520
Cost of bags and twine	800,000
Total variable cost/year	5,527,916
Total project cost/year = fixed + variable costs -------------	N9, 631,113

Project cost per ha = $\frac{9,631,113}{150}$ = ₦64, 207.4/ha

Project profits before tax = N4, 543,887 = 47%.

Result and Discussion (Project Evaluation)

See Tables 1, 2, 3 and 4 for rainfall, temperature, relative humidity and sunshine hours respectively at Bacita (data obtained from Bacita sugar company Field Technology Metrological Station) to ascertain the suitability of this location for the crops production.

The rotational penalty due to effect a cropping operation may have on the other one was reduced by rotating the production of maize and soybean yearly. Two crops shared the same set of equipment which reduces capital cost. Also maize consume a lot of inorganic Nitrogen requirements which was supplied by Nitrogen fixation property of soybean.

Table 5 is the cropping calendar done to show how the project operations were carried out with little overlapping and multi periods problems to maximize the usage of the machinery.

Evaluation and costing of this project was based on the existing data in Bacita, Nigeria. The project evaluation for the total gross margin revenue and the fixed and variable cost of input materials are summarized by the whole farm budgeting as shown above. This was based on the machinery selection and power requirement for each operation.

The total revenue margin was	N14, 175,000
The total cost of project was	N9, 631,113

Profit before tax was 47% which was more than recommended minimum 25% profit on the capital investment (Hunt, 1977). The project was found to be viable with good management and high operational efficiency.

Conclusion

With good soybean production management and planning, soybean production in Nigeria was found to be very profitable. The rainfall, temperature, relative humidity and sunshine period at Bacita was found very suitable for mechanized soybean production. The profit before tax was found to be above 45% of the project capital investment for well planned and managed production operations. This was possible by putting in place cropping calendar which was with little operation overlapping, little multi periods problems and maximizing the usage of agricultural tractor and implements for the two crops.

aTable 1: Monthly rainfall in millimetre (mm) (Bacita)

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
10 years Average (mm)	0	29	46	74	167	191	132	139	209	100	33	0

Table 2: Monthly minimum and maximum temperature in centigrade on 10years average (Bacita)

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Minimum(^{o}c)	15	20	24	25	24	23	22	22	22	22	19	15
Minimum(^{o}c)	34	37	38	37	33	31	30	30	31	32	34	34

Table3: Monthly relative humidity in percentage (Bacita)

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
10 years Average (%)	46	50	52	64	74	79	80	79	81	77	67	57

Table 4: Monthly sun shine hours (Bacita)

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
10 years Average (hrs)	7.3	7.5	7.2	7.5	7.7	7.3	5.9	5.0	6.3	7.4	8.3	8.0

Source: Nigeria Sugar Company, Bacita, Field Technology Metrological Station.

Table 5: Cropping Calendar for Soybean and Maize

Crop	Area (ha)	Jan (hr)	Feb (hr)	Mar (hr)	Apr (hr)	May (hr)	Jun (hr)	Jul (hr)	Aug (hr)	Sep (hr)	Oct (hr)	Nov (hr)	Dec (hr)
Maize	75		I(225)	I(225)	A(72)	B(40) C(800) D(48)	I(150) E(40)		F(58) N(58)				
Soybean	75				I(225)	I(225)	A(72)	B(40) C(80) D(48)	I(160)		F(58) H(58)		
Total	150(ha)	-	225	225	297	393	262	168	265	-	116	-	-

Key to Operations are: Plowing - A, Harrowing - B, Planting/ Fertilizer drilling – C, Chemical Spraying – D, Fertilizer application - E, Harvesting - F, Transporting - H, Weeding /Trash burning – I

Allotted figures were obtained as result machine and man hour required to carry-out each of the operation.

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