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Timeliness Cost of Planting Field Operations at Badala Farm in Bauchi State Nigeria

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Abstract
Position and time data were recorded during corn planting in Badala Farm Bauchi State Nigeria for 140 ha. Corn was planted from mid-June to mid-July, 2009 into the ploughed and harrowed crop's field. A questionnaire was used together with field experiment to evaluate timeliness cost. Vagaries of weather, optimum soil conditions, available field workdays, optimal level of machinery capacity were the significant explainers of yield variability. Maize yield was low 1.11ton/ha. Estimated number of work field days suitable for planting was 21 days. Operating speed was 2.2 Km/h. Field efficiency was 80 percent and the effective implement width as 6.4m.
Keywords: Timeliness Cost, Planting, Harvesting, Machinery Capacity and Crop Yield

1. Introduction

Many countries that had a deficit in food production became self-sufficient or began producing a surplus, particularly cereals. This positive development was encouraged by governments with guaranteed agricultural commodity prices and/or subsidies (Witney, 1995). Mechanisation was an important contributing factor in achieving this development, particularly increasing labour productivity and helping to increase yields (Witney, 1995). Once food surpluses arose, governments started implementing policies to reduce them since several of these foodstuffs were produced at higher costs than world market prices. A result of these policies was a considerable decrease in prices for some food commodities in the European Union (EU) during the 1990s. In consequence, cereal producing farmers have been facing a decreasing margin between gross revenues and machinery costs, not only in nominal terms but also in real terms (de Toro & Hansson, 2004).

Farm managers must develop a farm plan and acquire machinery and labour to perform necessary field operations every year, Determination of an optimal enterprise mix and its associated machinery complement depends on the farmer's ability to complete the require fieldwork in a timely manner. Machinery capacity is a measure of the rate at which a field operation may be performed, usually measured in acres per day or per hour (Sørensen & Nielsen, 2005). Too little machinery capacity may lead to delays in completing fieldwork, which often results in yield reductions or complete crop failure. Any yield losses have a negative effect on revenue and thus net farm income. Conversely, too much machinery capacity allows for timely field operations and thus reduces yield losses but increases the cost of production, which causes net farm income to decline.

In an economic sense, there is an optimal level of machinery capacity for every farm plan. To help achieve the optimal capacity level, producers need to realistically asses their capacity for field operations such as tilling, planting, cultivating and harvesting (Søgaard & Sørensen, 2004).

Timeliness is a function of the time that is available to perform fieldwork in relation to the farm's machinery capacity. Time available may be defined as the number of days suitable for fieldwork within a production period multiplied by the working hours in a suitable day. The variable "working hours per suitable day" is usually thought to have a relatively small variance (Rotz & Harrigan, 2005). However, the number of suitable days within a production period is an uncertain quantity that usually has a relatively large variance. Understanding the inherent uncertainty in this component of available time is an important step in the overall farm planning.

Probability of a working day (PWD) is the fraction of workable days to all days in a work season, which often is used in management of agricultural mechanization. For example it is used to determine timeliness cost, optimum capacity of a machine and the required machine capacity (Saglam & Tobi, 2011). Accurate information on the number of suitable days for field operations is important in design, development, and selection of efficient machinery systems for crop production (Khani, et al., 2011). In order to predict the amount of work that can be accomplished, the time available within the optimal period for the required operation must be known. The time available varies considerably from year to year as weather conditions vary. Selection of the optimal machinery set for long-term production on the farm depends upon accurate assessment of the days available for performing each field operation (Rotz and Harrigan, 2005).

Selecting farm machinery sufficiently large to complete the desired task in a timely manner that is cost effective has long been a challenge for farmers. Models and software have been developed to aid this task, but have been complicated and incomplete or limited to a small geographic region. Earl (1997) developed models to analyze timeliness costs and equipment capacity for corn planting. They concluded that three factors influenced timeliness costs: yield-planting date relationships, available working days, and daily effective field capacity.

The daily effective field capacities was determined from operating speed, implement width, field efficiency, and hours worked each day. Therefore, farmers must select a planter of sufficient width to plant their corn acreage based on the expected number of workdays, amount of time available per day, expected operating speed, and field efficiency, while accounting for yield planting date relationships (Lak and Almassi, 2011).

Information file estimating the field capacity of farm machines can be used to estimate the number of acres that can be completed per hour for different types and sizes of machines. Decision tool estimating the number of field days required, can be used to estimate the total number of field days required to complete a series of machinery operations, such as tillage and planting. These estimates can then be compared to the number of expected field days from this publication to test whether your machinery capacity is adequate for timely planting and harvesting (Huffman, 2009).

The factors determining timeliness are given by the equation (1) proposed by (ASAE) to determine timeliness costs for one operation.

$$Tc = \frac{k.A^2.Y.V}{Z.G.C;(Pwd)} \tag{1}$$

Where,

T_c = timeliness cost for the operations N/ha
k = timeliness loss coefficient (range from 0.0001 to 0.010), 1 day $^{-1}$
A = crop area involved (ha)
Y = Yield (kgha $^{-1}$)
V = value of the crop (Nkg $^{-1}$)
Z = 4 if the operation can be balanced evenly about the optimum time and 2 for premature or delayed schedule
G = expected time available for field work each day (h)
C = effective machine capacity (ha h^{-1})
P_{wd} = probability of a workday (decimal)

Management can more or less control machine capacity (machine width, speed, field efficiency) and daily working hours, but the probability or number of workdays for field operations is largely outside the farmers influence as these depend on the complex relationship between machinery system, soil and weather (Edwards and Boehlje, 1980). This relationship is usually site-specific with respect to soil, climatic and management factors (Hadas et al., 1988). In addition, the influence and interaction of the above factors on machinery costs implies that they should be considered simultaneously (Danok et al., 1980).

The aim of this paper is to estimate timeliness cost in Badala Maize farm to aid in decision making based on the yield, machinery performance and weather uncertainty.

2.Methodology

Badala farm is located in Savannah Ecological zone of Bauchi State and was considered as a study area. The farm lies on longitude 090 47'E and latitude 10023'N and cultivated 140 hectares of land during 2009 farming season.

A questionnaire was administered to the farm and provided the number of hectares cultivated, machinery and their sizes, implement used and their types, yield obtained per hectare, crop value as at the time of harvest, crop planted, and maintenance cost of the machinery, number of skilled and unskilled labourers. Data for multi-crop planter were recorded and it included the speeds of operation, row length, effective machine width, effective field capacity, theoretical field capacity, test duration and field efficiency were measured during the field operations as shown in Table 1.1.

Table 1.1: Field Performance of Planting Machinery during 2009 Raining Season for Multi-crop Planter.

Observation No.	A	B	C	D	E	F	G	H	I	J	K	L
1	150.20	6.52	1.90	47.30	0.48	0.34	5.69	4.63	81.37	9.68	99.29	4.60
2	140.40	6.00	2.10	40.23	0.12	0.26	4.52	3.39	75.00	8.40	80.96	2.74
3	280.50	6.35	2.40	70.12	0.12	-	15.73	12.49	79.40	17.78	100.00	12.49
4	350.70	6.47	2.40	90.23	0.30	0.59	26.31	20.47	80.88	22.61	99.35	20.34
5	320.90	6.49	2.20	87.24	0.22	0.42	22.40	18.17	81.12	20.78	99.52	18.08

A = Row length (m)
B = Effective machine width (m)
C = Speed of operation (kmph)
D = Test duration (min/ha)
E = Support (min/ha)
F = Delay (min/ha)
G = Theoretical Field Capacity (Cth) ha/h
H = Effective Field Capacity (Ce) ha/h
I = Field Efficiency (Eff) %
J = Man-machine productivity (Mmp) ha/h.
K = Man-machine activity (Mma) %
L = Man-machine performance (Mmpf) ha/h

Corn was planted between June 15, 2009 and July 15, 2009. Therefore, the cooperating farmer nearly finished with corn planting before the suggested planting period (Shroyer et al., 1996).

Timeliness factor was estimated based on the crop value lost per hectare (as compared with maximum possible crop value per hectare) for each day when completion of a given operation is delayed beyond the optimum operation date for which maximum crop value would occur. This phenomenon causes crop value to become less when operations are not performed at the best possible date when balanced against fixed cost of agricultural machinery the manager is faced with a decision problem as to the capacity of machinery system to select to meet the needs of a given farm size of a particular crop.

Quantitative determination of timeliness coefficient is a time consuming task because multiple test and measurements was made, many of which are under conditions in which crop value may be lost just for the purpose of securing timeliness loss data. In addition, each value is very much linked to the particular soil, weather and crop conditions, under which it was, developed (Nielsen, 1995). Thus, such values can only serve as estimates when applied under other circumstances.

The timeliness factors/coefficient was obtained through field measurements, laboratory analysis, farm records, metrological data, structured questionnaire and yearbooks, yield and time of starting and finishing of planting and harvesting operations, number of hectares farmed, crops planted, crop value and labour cost were administered to the farmer and were computed using equation (2).

As such the timeliness coefficient, k_t would be estimated from measured crop returns as they vary with the timing of machine operations (Yearbook, 1988) below:

$$K_t = \frac{Y_e}{(t_o - t)^2} \quad (2)$$

Where,

k_t = timeliness coefficient, decimal

y_o = yield loss, percent

$t_o - t$ = time deviation from optimum, days

2.1Fractional Utilization of Total Time

The fractional utilization of total time available for each operation (U values) were needed for the power and machinery estimation of timeliness cost procedure. Information relating to the schedule of the farm operation was earlier shown in Table 1.2 and was used together with the estimated machinery good field work days given in Table 1.3 to determine “U” values (fractional utilization of total time) for each operation. These average values are shown in Table 1.2 which is the ratio of actual time available for an operation within the total time or period scheduled for the operation. U value for the month of September was highest because of higher estimated good field work days during the period, even though is not part of the operations assessed but manual harvesting recorded the second highest with 0.258 as an average U values.

Table 1.2 Average 'U' Values for the Farm Operations (1999- 2009)

Operations	Time Available for operations (days)	Good Field Work	Ave. Estimated 'U' Values
1. Disc ploughing	31	3	0.097
2. Disc harrowing	31	3	0.097
3. Planting	30	2	0.067
4. Fertilizer broadcast (Pre-plant)	31	3	0.097
5. Chemical spraying	30	7	0.233
6. Fertilizer broadcast (Top-dress)	31	9	0.29
7. Manual harvesting	31	8	0.258

Table 1.3: Estimated Machinery Good Field Work Days for Bauchi Area from 1999- 2009.

Months	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Average
May	8	7	0	9	0	2	0	0	0	5	0	3
Jun	12	8	4	3	4	4	8	5	10	7	8	7
Jul	7	9	5	11	10	8	11	9	9	9	10	9
Aug	4	5	7	8	7	10	7	8	5	5	6	7
Sep	8	9	10	10	8	10	9	10	11	10	8	9
Oct	11	16	5	8	8	0	9	12	4	0	11	8
Total	50	54	31	49	37	34	44	44	39	36	43	43

3.Results and Discussion

3.1 Maize Yield

Maize yield was low in this study, the yield obtained after harvesting was 1.19 t/ha as shown in Table 1.4, partly due to erratic rainfall after silking and drought spell for 8 consecutive days during the grain filling stage. This confirms the findings of (Kowal & Kassam, 1978) who indicated that a maize crop might experience water stress if there was no rain for a period of five (5) days or more especially when the evapotranspiration rates were 4-6 min per day, a climatic condition which prevails in northern and Sudan Savannah zones.

In adequate or unreliable rainfall is perhaps the most important climatic factor affecting crop production in the tropics. Droughts have been reported to reduce the growth and yield of many crops including Maize (Zea Mays L.) (Tesha and Eck, 1983, 1984). The magnitude of yield reduction depends very much on the growth stage of the crop, the severity and duration of stress and the susceptibility or resistance of the particular Maize genotype to water stress (Lorens et al., 1987).

Another poor yields was due to the fact that very heavy rainfall occurred on the day of fertilizer application which washed away some of the fertilizers. The method of fertilizer application contravened the new method of fertilizer application of planting the fertilizer, instead of local method of "Ganaka" in Hausa meaning "this for you" (SassakawaGlobal2000, 1995).

Similarly, the low grain yield as captured in the questionnaire was due to the late planting of the crop, mid-June to mid-July, 2009 which is against the optimum planting dates of maize in the study area (mid-May to mid-June) (SassakawaGlobal 2000, 1995).

Planting should be done in time to allow rainfall to continue for six or seven weeks after flowering (Silking). This will guaranteed 4-5 t/ha of on-farm yield (Fajemtsin, 1992). Fatsuma (1989) observed that yield of maize due to delayed in planting time gave the highest grain yield 2.8 t/ha from 3 weeks after optimum planting time. Following this was 2.54 t/ha from 4 weeks after Maize planting treatment. This was contrary with 1.19 t/ha obtained in this study and also different as reported in the literature review as what is obtainable in Savannah agro-ecological zone.

The period just before and during the fertilization of flowers is one of the most weather-sensitive stages in the life of a fruiting or seed-bearing crop (Monteith, 1991). Yields are invariable poor when flowering occurs during drought or when flowers are exposed to high or low temperature that would otherwise cause no permanent damage to plants as observed by (Monteith, 1991).

The demand for water is greater during the silking and tasseling stage. Acute moisture shortage during this period will produce poorly filled ears as observed during the study

3.2Estimation of Timelines Cost

Timeliness factor for planting was 0.0021 percent per day for late sowing of spring wheat as reported by

(Gunnarsson & Hansson, 2004) and Gwarzo (1990) reported a timeliness factor of 0.017 percent per day. The two results falls within the data obtained at Badala farm which is 0.0781 percent per day. Timeliness factor for harvesting was reported by (Gunnarsson & Hansson, 2004) as 0.0092 percent per day and (Hunt, 1977) also obtained 0.003 as timeliness factor. Similarly, (Abdullahi, 1977) reported a timeliness factor of 0.0150 percent per day based on the research conducted at Samaru and when compared with what was obtained at Badala farm, 0.176 percent per day happens to be high.

de Toro and Hansson (2004) obtained the U values during planting and harvesting operations as 0.4 and 0.45 respectively. Similarly, (Gwarzo, 1990) obtained the U values for both planting and harvesting operations as 0.267 and 0.387 with same geo- ecological zone with Badala farms even though the values obtained at Badala farms is at higher side due to climate change. The values were 0.067 and 0.258 respectively.

Timeliness costs from an untimely planting and harvesting operations were estimated after extracting all the relevant information from the questionnaire and field work data with the value of crop after harvesting as N70 per kg, crop area involved 140 ha, yield 110 kg per ha as shown in Table 1.4. The estimated timeliness cost for planting and harvesting were N5, 691.35ha/day and N5, 732.65ha/day respectively.

Table 1.4: Estimated Timeliness Cost During Planting and Harvesting Operations

	Planting	Harvesting
Timeliness Factor Kt	0.0781	0.0176
Crop area involved (ha)	140	140
Yield Y (kgha)	1100	1100
Value of the crop V (N kg)	70	70
Expected time available for field work each day (h)	8	10
Effective field capacity (ha/hr)	11.83	1.19 (Gwarzo,1990)
Probability of a work day, P_{wd} (decimal)	0.233	0.258
4 if the operation can be balanced evenly about the optimum time and 2 for premature or delayed schedule	2	2
Timeliness cost for the operation, Tc (N/ha/day)	5691.35	5732.65

Conclusion

The timeliness penalties applied is a matter of concern. The quantitative relationships between machines, labour and timeliness costs were those expected according to established general farm management principles. Annual variations in timeliness costs were higher for the larger sets. Correspondingly, higher daily effective field capacity was linked to higher variability in timeliness costs, which should lead to higher risks.

Very low daily effective field capacity also led to peculiar effects on timeliness costs, particularly during rainy season when the ‘weaknesses’ of the smaller sets were revealed. Under such poor climate conditions, the effects of low machinery capacity were difficult to predict in advance since considerable areas were left due to erratic rainfall after silking and drought spell for 8 consecutive days during the grain filling stage.

The analysis found that timeliness costs of some considerable size (some N5, 691.35 and N5, 732.65 in Badala farm, respectively) were difficult to avoid during unfavourable climatic conditions on arable farms with sandy loam soils and reasonable machinery costs. This was associated with the low number of available workdays during the research.

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