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PERFORMANCE EVALUATION OF DISTRIBUTION CANAL (A CASE STUDY OF INSTITUTE OF AGRICULTURAL RESEARCH INSTITUTE OF AGRICULTURAL RESEARCH IRRIGATION EXPERIMENTAL PLOT, SAMARU ZARIA)

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Abstract

This study was conducted during the 2012/2013 irrigation season at the IAR irrigation experimental plot

Keywords: *irrigation, distribution system, distribution efficiency and distribution canal losses*

INTRODUCTION

Irrigation is practised in many parts of the world with the aim of providing water for crop growth when natural precipitation is in short supply and/or distribution is erratic. In dry areas, such as some parts of Northern Nigeria, where there is little rainfall, irrigation may provide a significant part of total water needs by the crops. In some parts of the middle belt of Nigeria, where rainfall is not as completely as reliable as in southern parts, growing crops need to be supplemented by irrigation whenever rainfall is scanty. Scarce water resources and growing competition for water will reduce its availability for

(Samaru Zaria), with the primary aim of evaluating the performance of a part of the distribution system and irrigation water distribution, as they affect the control, operation and equity. Block A1 was selected as the experimental site. Stage measurements were monitored at the selected stations in the distributary canal. Discharge was obtained from installed measurement structures (Weir and Spiles). The water distribution efficiencies and losses were determined for each of the selected stations. The results obtained from the study showed that 35.22 l/s on the average was recorded as discharge into the distributary canal and 22.39 l/s out of the distributary canal with average distribution efficiencies and losses of 65.04 % as against 90% recommended by FAO and 12.83 l/s respectively. The results obtained for the various farm units showed significant variations, both at the head-end and tail-end of the farm, hence low equity of distribution as a result of low water supply. Hence, the performance of the water distribution systems of the project area was found to be very low which can be attributed to poor canal condition, damaged structures and indiscriminate operation of release gates by the farmers, illegal diversions of water using water pumps and complete blockage by the head-end farmers are also contributing factors.

irrigated agriculture. Achieving high water use efficiency is a primary challenge in irrigated agriculture. Irrigation practices and techniques which aim at maximising crop production with minimum water utilization are fast evolving, and there is need for evaluation of these practices before adoption, which will include the employment of techniques and practices that deliver a more accurate supply of water to crops (FAO, 2002, English and Raja 1996). Apart from the effect of water management or water distribution within the project area, other factors include; engineering constructions, operations, monitoring and maintenance of the distribution structures such as gates in the distribution canal, the weir and the Spiles, which can result in inequitable water distribution within the project area

(Thomas, 1989). Where the appropriate quantity of water is released from the source, there is no guarantee that such amount will reach the field channels and the plots at their designed crop water requirement levels (Melvyn, 1989). In spite of the fact that considerable work has been done by various researchers on various aspects of the I.A.R irrigation farm, especially on conveyance and application efficiencies, not much has been done on the water distribution systems (the Canals and the Spiles), its evaluation as it affects the farmers and the crops grown within the project area. The current study on the assessment of the reliability of a conveyance canal was conducted at Institute of Agricultural Research (I.A.R) irrigation farm, Samaru Zaria during the 2012/2013 irrigation season and evaluation of the performance of the water diversion systems (Spiles) from the distribution canal for a particular block of the project area.

MATERIALS AND METHOD

The research project was carried out at Institute of Agricultural Research (I.A.R) irrigation farm, Samaru Zaria which lies between 11^{0}11'N and 7^{0}11"N, and at an altitude of 686m above the mean sea level, during the cool dry harmattan season between November and April. The climate of Samaru is described as dry, sub-humid with severe deficit of rainfall from October to May and a surplus From June to September with an annual rainfall of 1000mm (Igbadun 1997; Ramalan and Nwokeocha, 2000). The project is supplied with water from I.A.R Dam, which is pumped into the distribution canal from an underground conveyance pipe. Water distribution within the project area is by network of canal and turnouts (Spiles) as depicted in fig 3.1. The crops grown in the project area include; Sorghum, Sunflower, Maize and Onions. Border and Furrow irrigation are practiced in the Project area.

Experimental Set-up of the Field.

The study was conducted during the 2012/2013 irrigation season at the Irrigation Research Station, Samaru, which is one of the Research Stations of the Institute of Agricultural Research, Nigeria. Instruments for recording vital measurements for the study were located at places designated as stations and laboratory. Water allocation within the site is monitored and evaluated for necessary parameters throughout the irrigation season. Measurement locations were selected within the study area, taking note of areas with uniform flow and reliable geometric sections, so that approximate records could be easily established. Discharge measurements were monitored for each day the farmer takes water from the field channel into the plots throughout the growing season.

Flow Measurement Structures

For accurate measurement of flow on open channels it is desirable to install structure known as hydraulic structures. These structures cause flow to pass through critical depths. The structures also have a consistent relationship between the head and discharge as reported by Isrealsen et-al (1979).

a. Weirs

Weirs may be rectangular, trapezoidal or triangular in opening shapes. Gabrecht and Bos (1980) described a weir as a barriers placed in a stream to constrict the flow of water and cause it to fall over a crest. The basic general formula given by Francis for flow through such structures is;

$$\mathbf{Q = 0.0184(L - 0.1nH)H^{3/2}} \quad \text{--}\mathbf{2.1}$$

Where, Q = Coefficient of discharge which depends on the nature of the crest and the approach conditions. (L/s)

L = Length of the crest, cm

H = Height on the crest, cm

n = Number of end contractions

b. Spiles

Spiles made of bamboo, iron sheet or baked clay pipes, or wooden lath boxes can be used to take water out from the distribution canal.

Flows into borders or furrows are controlled by varying the number of Spiles or the elevation of the discharge end of the Siphon. The basic general formula given by Micheal, A.M (1978) for discharge through Spiles is given as;

$$\mathbf{Q = 0.65 \times 10^{-3}\, a\sqrt{2gh}} \text{ --2.2}$$

Where, $Q =$ discharge from siphon tube, L/s

$a =$ area of cross-section (internal) of Spile, cm^2

$g =$ acceleration due to gravity (981 cm per sec^2).

$h =$ effective head causing flow, cm.

Distributary Canal (DC) Measurement.

Four stations were chosen on the distributary canal supplying water to the study area in order to closely monitor flow in the canal. Station 1 at the upstream end, station 2 and 3 at the middle and station 4 at the downstream (tail-end of the canal). The float method was used for estimating and evaluating the discharge at the stations by using Velocity-area method of flow measurement, discharges at each station were determined. Weightless material of uniform size was used as a float material. A straight and fairly clean section of the canal was chosen. Two points (distance between two gates) were marked while the peg is carefully dropped 2 to 3m away from the first point. The time taken by the peg to transverse the first point to the second point was noted and recorded. The distance transverse divided by the time gives the velocity. This method was repeated several times and was done ten times for each day. The velocity calculated, according to Stern (1985), is called the surface velocity. The flow velocity or average velocity through the canal depends on flow depth and the effects of wind. The average velocity was obtained by multiplying the surface velocity with a factor **0.75**. The discharge through the canal was evaluated using Eqn. 2.3 The amount of water flowing at any time and at any place in water conveyance and distribution system, according to Gabrecht and Bos (1980), must be known in order to facilitate the proper administration of the irrigation system. Effective use of water requires that the flow rate and volume be measured and expressed quantitatively. Water measurement can generally be based upon the application of the definition equation which states that:

$$Q = AV \text{ ---2.3}$$

Where $Q =$ Flow rate, $m^3/_s$

$A =$ Cross sectional area, m^2

$V\ =\ $ Mean velocity of flow, $^{m}/_{s}$

The irrigation system distribution efficiencies and the distribution losses at the selected stations on the distributary canal were also evaluated using Eqn. 2.4 by Bos and Nugteren, (1982) and Eqn. 2.5 respectively.

Ed = Q2/Q1 --2.4

Where; $Q2\ =\ $ outflow discharge in the canal (m^3)

$Q1\ =\ $ inflow discharge in the canal (m^3)

The system distribution losses (DL) can also be evaluated as the difference between the discharges in the two field channels as given by Adewumi (1985).

Thus; DL = Q1 – Q2 ---2.5

RESULTS AND DISCUSSION

Introduction

A number of parameters were considered in the field evaluation of performance of irrigation water distribution systems at the I.A.R irrigation field. Discharges at selected stations on the distributary canal were monitored during the same period from which the water distribution efficiencies and losses were determined. Rating curves for the selected stations on the field were also developed.

Discharges from the Weir

The dimensions of the weir were adequately taken. Consequently, average discharges were monitored through the weir as shown on plate 1in appendix throughout the supply period. The results obtained are given in Table 3.1 in appendix. The results show a direct proportionality between the heads of the weir and the discharges from the weir. The average discharge from the weir was recorded to be 35.22 l/s as shown in Table 3.1 and Figure 3.1 both in appendix is a graph of upstream height (H) of water flowing through the weir into the canal to the discharge (Q) of water into the canal. The calibration curve shows that the higher the head (H), the higher the discharge.

Distribution Canal (DC) Discharge Efficiency

The different field channels on the experimental farm were selected and the measurement stations were designated as DC1, DC2, DC3 and DC4 respectively. The results of the discharges from the channels as shown in Table 3.2 (appendix) shows a decrease in the discharges from the head-end to the tail end of the distributary canal. This could be due to factors such seepage, outgrown weeds as shown on plate 1 (Appendix), siltation and illegal diversions as shown on plate 2 (Appendix).

The distribution efficiency of the distributary canal (DC) was found to be fluctuating. However, distribution efficiencies as shown in table 3.3 (appendix) ranges from 52.00% to 78.40% for the measurement on different days and time with the average conveyance efficiency gotten as 65.04%. The wide range in the conveyance efficiency could be attributed to a number of factors such as; inefficient operation of the conveyance pipe and pump.

The distributary efficiency (Ed) of the distributary canal was evaluated as the ratio of outflow to inflow discharges expressed as percentages. A summary of distribution efficiency for the selected stations on the distributary canal is shown in Table 3.3 (appendix). The results indicate a general decrease downstream along the canal. The water distribution systems performance of the IAR project cannot be accepted as satisfactory since shortage of irrigation water in some parts of the project area will eventually result in the reduction of land that can be put under irrigation.

Distribution Canal (DC) Discharge losses

The distribution losses of the canal were evaluated for the various stations as the difference in discharge between the outflow discharges and inflow discharges. The results obtained are shown in Table 3.4 (appendix). The results revealed varied distribution losses and this trend increases downstream. The distribution losses range from 5.13 l/s to 24.18 l/s. The average loss is gotten as 12.83. The highest conveyance loss was recorded for the distributary canal which can be attributed mainly to the general lack of maintenance of the canal structure, notably siltation and outgrown weeds within the canals.

A number of reasons could be attributed to the variations in discharge and low values of efficiencies and high water losses for the water distribution system within the study area; most of the gates in the distribution canal are not functional (plate 3, Appendix) and thus reducing discharge downstream. Also, illegal diversions of water by farmers, through channel banks (with the use of pumping machine) divert part or whole water to individual farm units.

Insufficient water at the tail-end of the field channel is sometimes due to complete blockage of water flow in the channel by the upstream farmers in order to divert the whole water into their farm units. Such blockages will often take long time; deny all farmers at tail-end of the field channel the right of water use as seen in plate 2 (Appendix).

CONCLUSION

The performance of the water distribution systems of the project area was found to be very low which can be attributed to poor canal condition, damaged structures and indiscriminate operation of release gates by the farmers, illegal diversions of water using water pumps and complete blockage by the head-end farmers are also contributing factors.

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APPENDIX

Table 3.1: Discharge Records from the Weir

DATE	HEAD (CM)	DISCHARGE (L/S)
04/02/2013	8.95	23.54
07/02/2013	8.75	22.74
11/02/2013	10.15	28.58
14/02/2013	10.00	27.93
18/02/2013	9.00	23.75
21/02/2013	11.50	34.65
25/02/2013	10.90	31.90
28/02/2013	10.75	31.23
04/03/2013	12.25	38.22
07/03/2013	11.75	35.83
11/03/2013	12.98	41.81
14/03/2013	13.00	41.91
18/03/2013	12.28	38.37
21/03/2013	15.12	53.03
25/03/2013	14.69	50.70
28/02/2013	14.51	49.73
01/04/2013	12.08	37.40
04/04/2013	11.21	33.32
08/04/2013	11.70	35.60
11/04/2013	12.28	38.37
15/04/2013	10.50	30.11
18/04/2013	10.22	28.88
22/04/2013	11.20	33.27
25/04/2013	10.65	30.78
29/04/2013	12.36	38.76

TOTAL	288.78	880.41
AVERAGE	11.55	35.21
SD	1.69	8.02

Table 3.2: Summary of Discharges Recorded at from the Spiles

DATES	SPILE 1	SPILE 2	SPILE 3	SPILE 4	TOTAL Q
04/02/2013	3.70	4.18	4.81	5.38	18.07
07/02/2013	3.63	4.18	4.23	5.27	17.31
11/02/2013	4.00	4.55	6.02	6.26	20.83
14/02/2013	3.44	4.40	5.36	5.79	18.99
18/02/2013	3.75	4.23	5.09	5.55	18.62
21/02/2013	4.40	4.81	6.20	6.39	21.80
25/02/2013	4.23	4.76	6.07	6.38	21.44
28/02/2013	4.06	4.76	6.04	6.37	21.23
04/03/2013	4.81	5.82	6.22	6.48	23.33
07/03/2013	4.58	5.21	6.22	6.40	22.41
11/03/2013	5.21	6.25	6.59	7.05	25.10
14/03/2013	6.08	6.07	6.38	6.67	25.20
18/03/2013	5.05	5.97	6.33	6.51	23.86
21/03/2013	6.32	6.93	7.48	8.12	28.85
25/03/2013	6.08	6.39	7.04	7.20	26.71
28/02/2013	5.62	6.38	6.66	7.20	25.86
01/04/2013	4.76	5.66	6.14	6.44	23.00
04/04/2013	4.34	4.76	6.15	6.32	21.57
08/04/2013	4.79	5.86	6.14	6.46	23.25
11/04/2013	5.05	5.97	6.33	6.51	23.86
15/04/2013	4.03	4.73	6.03	6.30	21.09
18/04/2013	4.03	4.60	6.06	6.29	20.98
22/04/2013	4.34	4.76	6.16	6.35	21.61
25/04/2013	3.97	4.70	5.99	6.31	20.97
29/04/2013	4.87	6.00	6.34	6.53	23.74
AVERAGE	6.77	6.41	5.61	4.81	22.39

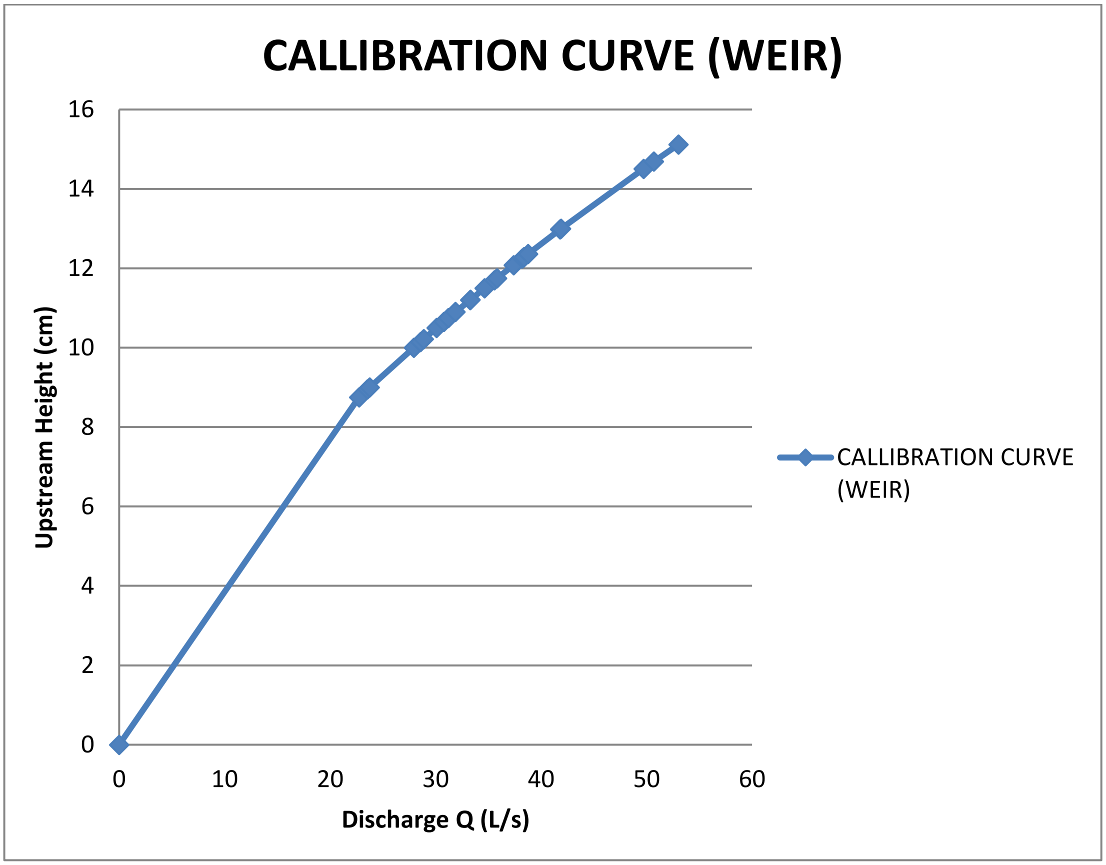
Table 3.3: Distributary Canal Efficiencies

DATE	DISCHARGE FROM WEIR(l/s)	TOTAL Q (Spiles) l/s	Efficiency (%)
04/02/2013	23.54	18.07	76.76
07/02/2013	22.74	17.31	76.12
11/02/2013	28.58	20.83	72.88
14/02/2013	27.93	18.99	67.99
18/02/2013	23.75	18.62	78.40
21/02/2013	34.65	21.80	62.91
25/02/2013	31.9	21.44	67.21
28/02/2013	31.23	21.23	67.98
04/03/2013	38.22	23.33	61.04
07/03/2013	35.83	22.41	62.55
11/03/2013	41.81	25.10	60.03
14/03/2013	41.91	25.20	60.13
18/03/2013	38.37	23.86	62.18
21/03/2013	53.03	28.85	54.40
25/03/2013	50.70	26.71	52.68
28/02/2013	49.73	25.86	52.00
01/04/2013	37.40	23.00	61.49
04/04/2013	33.32	21.57	64.74
08/04/2013	35.60	23.25	65.31
11/04/2013	38.37	23.86	62.18
15/04/2013	30.11	21.09	70.04
18/04/2013	28.88	20.98	72.65
22/04/2013	33.27	21.61	64.95
25/04/2013	30.78	20.97	68.13
29/04/2013	38.76	23.74	61.25
TOTAL	880.41	559.68	
AVERAGE	35.22	22.39	65.04
SD	8.02	2.72	

Table 3.4: Distributary Canal Losses

DATE	DISCHARGE FROM WEIR(l/s)	TOTAL Q (Spiles) l/s	LOSSES (l/s)
04/02/2013	23.54	18.07	5.47
07/02/2013	22.74	17.31	5.43
11/02/2013	28.58	20.83	7.75
14/02/2013	273	18.99	8.94
18/02/2013	23.75	18.62	5.13
21/02/2013	34.65	21.80	12.85
25/02/2013	31.90	21.44	10.46
28/02/2013	31.23	21.23	10.00
04/03/2013	38.22	23.33	14.89
07/03/2013	35.83	22.41	13.42
11/03/2013	41.81	25.10	16.71
14/03/2013	41.91	25.20	16.71
18/03/2013	38.37	23.86	14.51
21/03/2013	53.03	28.85	24.18
25/03/2013	50.70	26.71	23.99
28/02/2013	49.73	25.86	23.87
01/04/2013	37.40	23.00	14.40
04/04/2013	33.32	21.57	11.75
08/04/2013	35.60	23.25	2.35
11/04/2013	38.37	23.86	1.51
15/04/2013	3011	21.09	9.02
18/04/2013	28.88	2098	7.90
22/04/2013	33.27	21.61	11.66
25/04/2013	30.78	20.97	9.81
29/04/2013	38.76	23.74	15.02
TOTAL	880.41	559.68	
AVERAGE	35.22	22.39	12.83
SD	8.02	2.72	

Fig 3.1: Calibration Curve for the Weir



PLATES

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