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Evaluation of Drip Irrigation Based on Hydraulic Parameters

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ABSTRACT

Drip irrigation is a method which minimizes the use of water and fertilizer by allowing water slowly to the roots of the plants either in to the soil surface or directly in to the root zone, through a net work of valves, pipes, tubing and emitters. As the drip irrigation installed in large scale, in Andhra Pradesh state through APMIP (Andhra Pradesh Micro Irrigation Project) which was launched in Nov' 11th, 2003 covers an area of 4.40 lakh ha drip and 2.14 lakh ha sprinkler with total of 6.54 lakh ha up to 2010-11. As the drip systems are having many maintenance functional problems in the farmer's fields and farmers experience maintenance problems under drip irrigation, a study has been taken up to evaluate and assess the performance of these systems in the fields with banana crop of selected mandals in Guntur district. The results enlights a brief picture about pressure, discharge and horsepower of pump set variations of the drip systems that generally occur due to design parameters.

Key words : Drip irrigation, Discharge, Horse power, APMIP

Water is the precious natural source, a basic human need and a prime national asset. The extent to which the water is plentiful or scarce, clean or polluted, beneficial or destructive, profoundly influence the extent and quality of human life. The relentless increase in population creates acute demand of water which require careful planning and management. The available water resources are to be optimally harnessed and beneficially utilized with appropriate priorities of use.Sustainability of food production depends on sound and efficient use of water and conservation practices consisting mainly irrigation development and management. Agriculture must provide food for the rising population and save water for other uses. Hence, there is a need to develop modern irrigation technologies to increase the area under irrigation and enhance agricultural productivity per unit volume of water .

Domienico *et al.* (2006) proposed a procedure to evaluate head losses in drip laterals, based on constant outlet, discharge assumption for quick evaluation of total head losses in drip irrigation lines. Total head losses values are measured on 15 commercially available co extruded laterals were compared with those obtained by using the newly proposed methodology. Relative errors are on the pressure head estimation for the examined cases were always $\pm$ 2.4%. It was found that the pressure requires operating the farthest dripper ranges between 3 to 7m with respect to length of lateral.

Algobhari (2005) conducted experiments on evaluation of 10 drip regions of Saudi Arabia. Results of field evaluation showed that the irrigation performances are lower than the accepted values for evaluated systems and that the ten systems showed varied performance in their uniformities of the applied water.

Narayana Murthy and Deshpande (2004) in their studies on drip irrigated sugarcane fields determined that productivity was 23% higher than that of flood irrigation method with water saving about 44% per hectare and electricity saving of about 1059 KWh / ha. The above are inferred that investment in drip irrigation for sugarcane cultivation remains economically viable even without government subsidy. Alberts *et al*. (1987) predicted minor head losses at emitter insertions along drip laterals by obtaining a derivation from Bac langer's theorem and analyzed the classic formula that includes a friction coefficient 'K' multiplied by kinetic energy term. A relationship was established for 'K' as a function of some emitter geometric characteristics. An experimental procedure was also developed to determine the minor losses *in- situ*, in the laboratory or in the field. An approach is suggested to calculate either 'K' or the emitter equivalent length 'l_e' as a function of lateral head losses, inlet head, and flow rate.

MATERIAL AND METHODS

Study area

The study area pertains in 40 banana fields of Mangalagiri and Thulluru mandals of Guntur district, Andhra Pradesh .The data was collected from Andhra Pradesh Micro Irrigation Project Office(APMIP), Guntur in order to assess the performance evaluation

Evaluation of Technical parameters

i) Evaluation of pressure

As per the standard practice of drip irrigation system a pressure variation of 20% is allowed in Indian conditions for better performance. To ascertain the same in the farmer's fields, the pressure at the inlet end and at the end plug of the laterals were measured with the help of a pressure gauge in forty locations.

ii) Evaluation of discharge variation

As per the standard practice, a variation of 8 to10 % may be allowed in the discharge from the inlet to the end plug of the lateral. To ascertain the same, the discharge of the emitters of a randomly selected laterals at three locations. i.e. At the inlet, middle, and near the end plug were measured, and average discharge was calculated. The discharge of the emitters was measured accurately by volumetric method with help of a one liter measuring cylinder and a stop watch used for the measurement of time.

iii)Calculation of HP requirement of the pump

To calculate the size of the motor, the frictional head loss in the laterals. Sub mains and mains have to be observed. To estimate the friction head of drip irrigation laterals and Darcy -Weishbach equation for smooth pipes in micro-irrigation can be combining with the Blassius equation as follows:

$$H_{fl} = K \times L \times Q^{1.75} \times D^{-4.75} \times F \qquad (1)$$

Where,

H_{fl} = Friction loss in lateral pipe,

K = A constant whose value is 7.89×10^5

L = Length of the pipe in, m

Q = Rate of flow in pipe, lit/sec

D = Diameter of the pipe, mm

F= Factor for multiple outlet flow.

'F' values are calculated based on Christianson's formula. 'F' values for different number of outlets are is given table general value of 'F' is 0.376 for laterals sub main 0.389.

HP can be estimated by equation

$$H.P = \frac{Q \times H}{75 \times \eta_p \times \eta_m} \qquad (2)$$

Where :

H.P	=	Horse power of the electric motor.
H	=	Total head requirement of the pump, m
Q	=	Capacity of the drip irrigation system L/S.
$\eta p, \eta m$	=	Efficiency of the pump & motor.

List of farmers, code numbers, with their exetent (Ac) was given in Table 1.

RESULTS AND DISCUSSIONS

3.1 Evaluation of technical parameters

The evaluation of technical parameters was taken up to check whether the operation of the drip systems is under the limits of the standards or not. Pressure drop 20% in the laterals sub mains indicates the best range for the performance of the system. The variation of 10% in the rated discharge is acceptable for a drip system.

Table 1. List of farmers, code numbers, with their exetent (Ac)

F1	3.0	F11	2.0	F21	5.0	F31	3.0
F2	2.0	F12	3.5	F22	3.0	F32	2.5
F3	1.0	F13	2.5	F23	2.5	F33	2.0
F4	4.0	F14	2.0	F24	3.0	F34	3.2
F5	1.5	F15	3.0	F25	4.0	F35	2.7
F6	3.5	F16	5.0	F26	4.5	F36	1.7
F7	4.0	F17	4.5	F27	5.5	F37	2.4
F8	1.5	F18	3.7	F28	3.0	F38	1.6
F9	4.5	F19	4.2	F29	2.5	F39	2.0
F10	5.0	F20	4.5	F30	2.0	F40	2.5

Table 2. Discharge variation in the lateral pipes in forty farmers fields

Field no	Extent (Ac)	Rated discharge (Lph)Qr	Discharge Readings(Lph)			Average discharge (Lph)Qa	%of Discharge variation $\frac{(Qr-Qa) \times 100}{Qr}$
			Location 1	Location 2	Location 3		
F1	3.0	4	4.0	3.8	3.9	3.87	3.25
F2	2.0	4	3.6	3.4	3.4	3.47	13.25
F3	1.0	4	3.0	3.0	3.0	3.00	0
F4	4.0	4	3.8	3.6	3.6	3.73	6.75
F5	1.5	4	4.0	3.8	3.8	3.90	2.5
F6	3.5	4	3.8	3.5	3.5	3.67	8.25
F7	4.0	4	3.8	3.7	3.7	3.73	6.75
F8	1.5	4	3.7	3.5	3.5	3.57	10.75
F9	4.5	4	3.8	3.8	3.7	3.77	5.75
F10	5.0	4	4.2	4.0	4.0	4.07	1.75(+)
F11	2.0	4	3.1	3.2	3.0	3.10	22.5
F12	3.5	4	3.2	3.2	3.2	3.20	20
F13	2.5	4	3.6	3.5	3.5	3.57	10.75
F14	2.0	4	3.6	3.2	3.2	3.40	15
F15	3.0	4	3.6	3.6	3.5	3.57	10.75
F16	5.0	4	4.2	4.2	4.0	4.13	3.25(+)
F17	4.5	4	4.0	4.0	4.0	4.00	0
F18	3.7	4	4.0	4.2	4.0	4.13	3.25(+)
F19	4.2	4	3.9	3.8	3.7	3.80	5
F20	4.5	4	4.2	4.0	4.0	4.03	1.75
F21	5.0	4	3.6	3.6	3.7	3.63	9.25
F22	3.0	4	3.8	3.8	3.6	3.73	6.75
F23	2.5	4	3.9	3.8	3.7	3.80	5
F24	3.0	4	4.2	4.2	4.0	4.13	3.25
F25	4.0	4	4.1	4.1	4.0	4.07	1.75
F26	4.5	4	4.0	4.0	4.0	4.00	0
F27	5.5	4	3.9	3.8	3.6	3.77	5.75
F28	3.0	4	4.2	4.1	4.0	4.10	2.5
F29	2.5	4	3.2	3.0	3.0	3.07	23.25
F30	2.0	4	3.6	3.4	3.4	3.47	13.25
F31	3.0	4	3.8	3.7	3.6	3.70	7.5
F32	2.5	4	4.2	4.0	4.0	4.07	1.75
F33	2.0	4	3.9	3.9	3.8	3.87	3.25
F34	3.2	4	4.0	4.0	3.9	3.97	0.75
F35	2.75	4	4.2	4.1	4.0	4.10	2.5
F36	1.7	4	3.8	3.5	3.5	3.60	10
F37	2.4	4	3.6	3.2	3.2	3.47	13.25
F38	1.6	4	4.0	4.0	4.0	4.00	0
F39	2.0	4	3.4	3.2	3.2	3.27	18.25
F40	2.5	4	4.2	4.1	4.0	4.10	2.5

Table 3. Pressure variation in the laterals of forty farmers fields.

Field no	Area(Ac)	Inlet pressure (Kg/cm^2)	Out let pressure (Kg/cm^2)	% of Pressure drop
F1	3.0	1.0	0.7	25
F2	2.0	1.2	0.9	25
F3	1.0	1.2	1.1	12
F4	4.0	1.1	0.8	27
F5	1.5	1.2	0.9	25
F6	3.5	1.0	0.6	40
F7	4.0	1.1	0.7	36
F8	1.5	0.9	0.5	44
F9	4.5	1.0	0.7	30
F10	5.0	1.2	0.8	33
F11	2.0	1.3	1.0	23
F12	3.5	1.2	1.0	16.7
F13	2.5	1.1	0.9	18.21
F14	2.0	1.2	1.0	16.7
F15	3.0	1.0	0.9	10
F16	5.0	1.2	1.0	16.7
F17	4.5	1.2	1.0	16.7
F18	3.7	1.1	1.0	9.1
F19	4.2	1.3	1.1	15.4
F20	4.5	1.0	0.8	20
F21	5.0	1.4	1.2	14.3
F22	3.0	1.3	1.1	15.4
F23	2.5	1.5	1.3	13.3
F24	3.0	1.4	1.2	14.3
F25	4.0	1.6	1.4	12.5
F26	4.5	1.0	0.8	20
F27	5.5	0.9	0.7	22.2
F28	3.0	1.0	0.8	20
F29	2.5	0.8	0.7	12.5
F30	2.0	0.7	0.8	11.1
F31	3.0	0.9	0.7	22
F32	2.5	1.0	0.9	10
F33	2.0	1.0	1.0	16.6
F34	3.2	1.1	1.1	15.4
F35	2.7	1.2	1.2	0
F36	1.7	1.0	1.0	0
F37	2.4	0.8	0.8	20
F38	1.6	0.7	0.7	12.5
F39	2.0	1.2	1.0	16.6
F40	2.5	1.0	0.8	20

Table 4. Calculations of HP requirements of selected drip irrigation systems

Field no	Extent (Ac)	Discharge (Lps)	Existing HP	Head Loss Readings(m)						Calc. HP
				Hfm	Hfs	Hfl	Hsys	Hsuc	Htot	
F1	3.0	12.51	3.0	1.8	1.5	0.9	15.0	13	28.0	4.6
F2	2.0	8.34	3.0	0.4	1.6	1.4	14.3	13	27.3	3.0
F3	1.0	4.17	3.0	0.3	1.6	1.5	13.0	13	26.0	1.5
F4	4.0	16.68	5.0	1.5	2.2	1.0	16.2	15	3.12	6.9
F5	1.5	6.26	3.0	1.3	1.6	0.3	13.3	13	26.3	2.2
F6	3.5	14.60	5.0	2.0	1.4	0.1	15.0	15	30.0	5.9
F7	4.0	16.68	5.0	1.3	2.3	2.0	17.2	15	32.2	7.1
F8	1.5	17.72	5.0	2.4	2.3	4.6	20.8	15	35.8	8.5
F9	4.5	18.77	5.0	2.8	3.3	2.8	20.4	15	35.4	8.9
F10	5.0	20.85	7.5	1.0	1.4	2.2	16.2	22	38.2	10.5
F11	2.0	8.34	3.0	2.2	1.8	1.0	15.5	15	30.5	3.4
F12	3.5	14.60	3.0	1.5	1.6	1.1	16.0	18	34.2	6.7
F13	2.5	10.43	3.0	1.0	1.5	1.1	18.1	15	33.1	4.6
F14	2.0	8.34	3.0	2.1	1.8	1.2	17.5	15	32.5	3.6
F15	3.0	12.51	3.0	3.1	2.1	1.2	16.5	13	29.5	4.9
F16	5.0	20.85	7.5	3.9	2.5	2.2	18.0	18	36.0	10.1
F17	4.5	18.76	7.5	3.7	2.4	2.2	18.0	18	36.0	7.5
F18	3.7	15.63	7.5	3.6	2.3	1.8	15.0	18	33.0	6.9
F19	4.2	17.72	7.5	3.5	2.2	1.6	18.0	13	31.0	7.3
F20	4.5	18.76	7.5	3.5	2.2	1.6	18.0	20	38.0	9.5
F21	5.0	20.85	7.5	3.9	2.5	2.2	18.0	18	36.0	10.0
F22	3.0	12.51	5.0	3.1	2.2	0.8	16.5	18	34.5	5.7
F23	2.5	10.42	3.0	1.8	1.9	1.1	14.0	18	32.0	4.4
F24	3.0	12.51	3.0	1.6	1.8	1.0	18.0	18	36.0	6.0
F25	4.0	16.68	7.5	1.2	1.6	1.1	21.0	24	45.0	10.0
F26	4.5	18.76	7.5	1.0	1.6	1.2	20.0	24	45.0	11.2
F27	5.5	22.93	10.0	1.5	1.4	1.3	20.0	21	41.0	12.5
F28	3.0	12.51	3.0	1.1	1.2	1.1	21.0	20	41.0	6.8
F29	2.5	10.42	3.0	0.8	1.1	0.9	15.0	18	33.0	4.5
F30	2.0	8.34	3.0	0.9	1.1	0.8	15.0	18	33.0	3.6
F31	3.0	12.51	5.0	1.4	1.2	0.8	15.0	18	33.0	5.5
F32	2.5	10.42	3.0	1.1	0.9	0.8	14.0	13	27.0	3.7
F33	2.0	8.34	3.0	1.0	0.8	0.9	14.0	13	27.0	3.0
F34	3.2	13.34	3.0	1.1	1.0	1.0	18.0	14	36.0	6.4
F35	2.7	11.47	5.0	0.8	0.9	1.1	18.0	14	32.0	4.9
F36	1.7	7.30	3.0	1.2	1.0	0.9	15.0	13	28.0	2.7
F37	2.4	10.01	3.0	1.0	0.9	1.1	15.0	15	30.0	4.0
F38	1.6	6.67	3.0	1.1	1.0	0.9	15.0	13	28.0	2.5
F39	2.0	8.34	3.0	1.1	1.1	1.0	15.0	18	33.0	3.7
F40	2.5	10.04	3.0	1.0	1.0	0.9	15.0	18	33.0	4.4

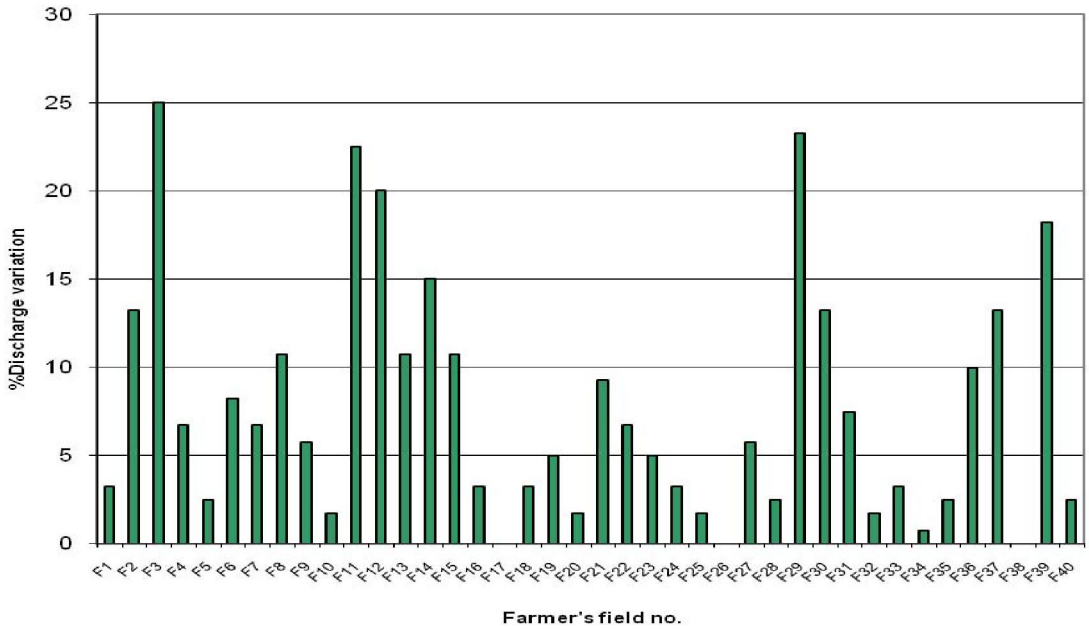

Fig1 Discharge variation in farmers' fields surveyed

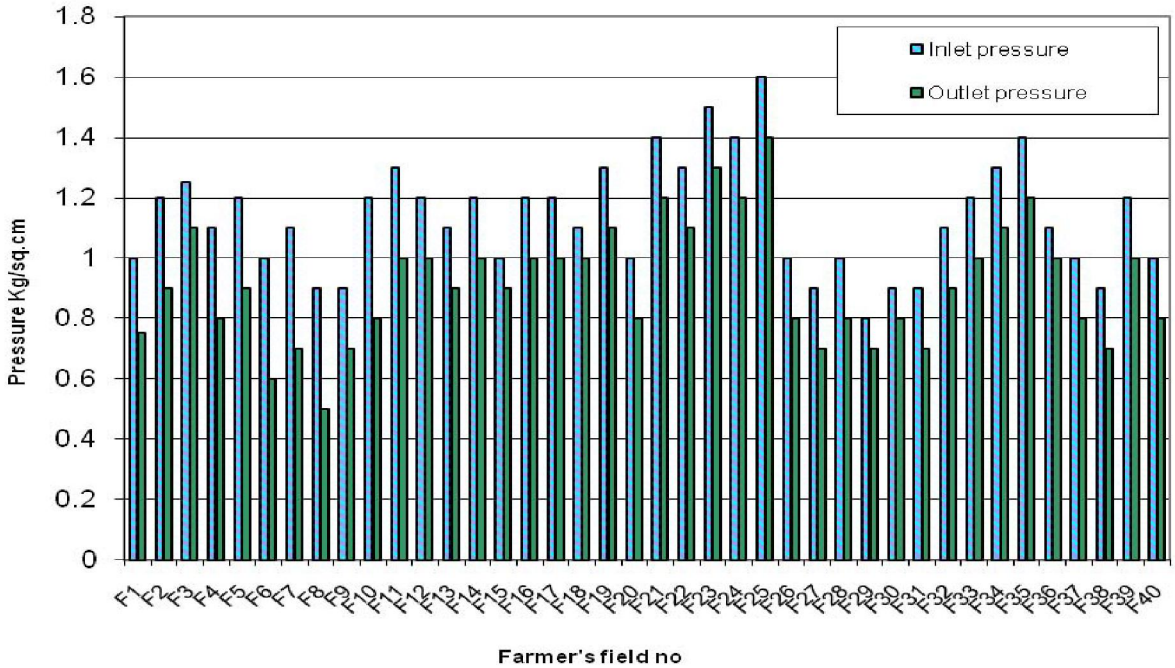

Fig.2 Inlet and outlet pressures in various fields

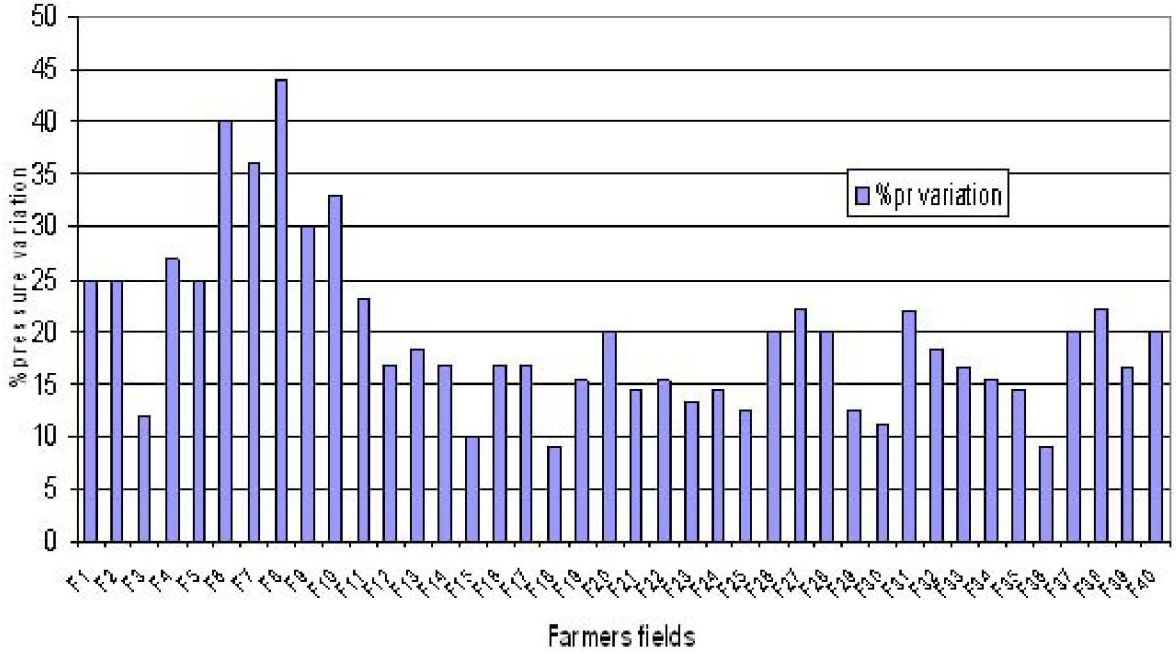

Fig.3 Pressure variation different farmers fields

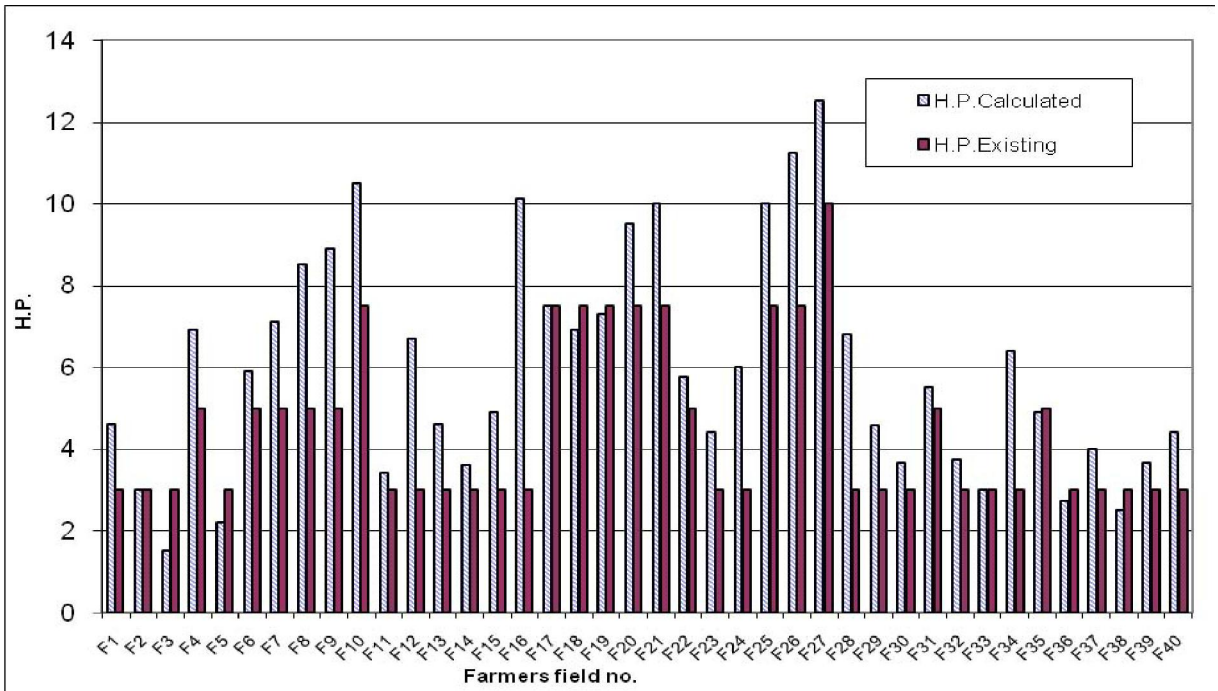

Fig.4 Calculated and Existing HP of motor pumpsets

The observations of the rated discharge and, pressure at different locations are shown Tables 2 and 3 respectively.

Discharge variations

The results of the study revealed that out of the forty fields inspected, the discharge of drippers of twenty one fields shows little variation from the rated discharge. The best discharge variations between 1 to 10% (F1, F4, F5, F6, F7, F9, F19, F20, F21, F22, F23, F24, F25, F27, F28, F31, F32, F33, F34, F35 & F40). Three fields are not matching with the discharge variation of 20% to 30% (F11, F12, & F29). Nine Fields varied between 10% to 20% which are considered to be normal (F2, F8, F13, F14, F15, F30, F36, and F37 & 39). Three fields have shown excess discharge than the rated (F10, F16, F18). The remaining four fields (F3, F17, F26 & F28) have shown the exact rated discharge i.e 4 lph.

Pressure variation

i) Twenty one fields proved best with pressure variation between 10% to 20% (F3, 13, 14, 15, 16, 17, 18, 20, 21, 22, 23, 24, 25,29, 30, 32, 33, 34, 35, 36 & 39).

ii)Fourteen fields are showing acceptable range pessure drip of 20% to 30% (F1, 2, 5, 10, 11, 12, 21, 26, 27, 28, 31, 37, 38 & 40).

iii) The remaining five fields are (F6, F7, F8, F9, F10) are the pressure drop of above 30%. This is beyond the standards with poor performance.

HP Variation

For 31 fields the size of the pump is not sufficient to operate the system (F6, F8, F9, F10, F11, F12, F13, F14, F15, F16, F17, F20, F21, F22, F23, F24, F25, F26, F27, F28, F29, F30, F31, F32, F34, F35, F37, F39 & F40) as the calculated HP is more than the existing HP which proved that the design of the drip system is inadequate to operate for the six fields F3, F5, F18, F19, F36, F38),for the other three fields calculated HP is matching with existing HP of drip systems (F2, F17, F33).

The observations of hp of pump set of different locations are shown Table 4

The above data is represented graphically are shown by graphs no 1, 2 3 and 4.

Conclusions

The following conclusions can be drawn from the present study. out of 40 drip installation.

1.It was found that 53% falls in acceptable range and 22% not acceptable. However, the exact discharge shows only 10 % of the total installations. the discharge variation is best (1 to 10%) in 53% acceptable range (10 to 20%), 22% not acceptable range is (above 20%) 15%. Exact discharges shows 10% only.

2.The pressure variation is best in 53% (10 to 20%) of total installations. Acceptable are in 35% (20 to 30%) installations and 12% (>30%) are not acceptable range

3. The size of the pump set (HP) is not sufficient for 77% of the systems to operate the drip system. More size than required capacity is 15% and suitable size of pumps are for 8% only.

Therefore from above conclusions it is noticed that, there is a lot of design lacunas in most of the drip installation in entire country as well as Andhra Pradesh state. Hence special attention is required on the drip irrigation hydraulic design before installing in the farmers' fields. so that, corers of money will save to farming community and yield quality also improved.

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