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Effect of planting density, irrigation and fertigation levels on water saving and water use efficiency of brinjal (*Solanum melongena* L.)

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ABSTRACT : A field experiment was conducted during *Rabi-hot* weather of 2009-2010 at Department of Agronomy, College of Agriculture, Dapoli, Dist. Ratnagiri (M.S.). The soil of experimental field was sandy clay loam in texture and moderately acidic in reaction, medium in available N, low in available P_2O_5 and high in K_2O content. The experiment was laid out in Split Plot Design consisted of three planting density *viz.*, S_1-75×75cm, S_2-75-50×90cm, S_3-175-50×50cm and three irrigation levels (I_1-100 % ET_{crop}, I_2-80 % ET_{crop}, I_3-60 % ET_{crop}). The sub plot treatment comprised of two fertigation levels *viz.*, F_1-100 per cent RDF through drip (WSF), F_2-80 per cent RDF through drip (WSF). Thus, these eighteen treatments combinations were replicated thrice. Field water use efficiency (FWUE) was maximum *i.e.* 46.91 q ha^{-1}-cm in treatment combination of plant spacing S_3 (175-50×50cm) with I_3 (60 % ET_{crop}) and F_1 (100 % RDF through drip). The treatment wise saving of water over check basin irrigation method was 66.94, 78.47, and 88.94 per cent in the treatments I_1 (100 % ET_{crop}), I_2 (80 % ET_{crop}) and I_3 (60 % ET_{crop}), respectively.

Key Words : Water saving, Field water use efficiency (FWUE), Planting density, Irrigation levels, Fertigation levels, Brinjal

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Among the several inputs, water is one of the crucial factor for crop production. Its economic and efficient utilization becomes quite imperative. Various technologies have been adopted for its higher use efficiency. Maintaining available soil moisture at low water tension and almost constant during entire growth period through drip irrigation was beneficial in terms of economic yield and could save up to 50 per cent of irrigation water (Bafna *et al.*, 1993 and Shelke *et al*., 1999). Efforts are made to enhance its efficient use. The volume of water supplied through drip is equal to the consumptive use of plants thereby minimizing conventional losses as deep percolation and runoff, which gives better water use efficiency.

Fertigation is a method of application of plant nutrients through drip irrigation effecting saving of water and simultaneously enhancing the yield and quality of produce (Ibrahim, 1992). The fertilizer and water saving were observed to the extent of 50 and 52.6 per cent under drip irrigation when compared with surface irrigation (Pawar *et al.*, 1993). Fertigation allows to permit an accurate control of water and nutrients in the immediate vicinity of the root system that prevents fertilizer contamination of ground water through leaching below the crop root zone. Through fertigation, fertilizers are used efficiently by the crop while under traditional methods fertilizer use efficiency is low (Hebbar *et al*., 2004).

Plant spacing is also a central factor which plays a significant role in water saving of any crop since it grants the possibility to the plants for efficient absorption and utilization of water and their optimum distribution with minimizing the competition or density of weed that results into higher water use efficiency. The optimum plant spacing gives the right plant density for optimum growth and yield of vegetable crop due to increase in WUE (Gopalakrishnan, 2007). Water saving and water use efficiency of brinjal can be altered by adjusting plant spacing and managing the irrigation and nutrition. Hence, the present study was aimed at evaluating the performance of eggplant (*Solanum melongena* L.) subjected to different plant spacing, irrigation and fertigation levels.

Research Procedure

A field experiment was conducted during *Rabi-hot* weather of 2009-2010 at Department of Agronomy, College of Agriculture, Dapoli, Dist. Ratnagiri (M.S.). The soil of experimental field was sandy clay loam in texture and moderately acidic in reaction, medium in available N, low in available P_2O_5 and high in K_2O content. The present investigation was carried out in split plot design. The main plot treatments were different plant spacing (three) *viz.*, S_1-75×75cm, S_2-75-50×90cm, S_3-175-50×50cm and three irrigation levels (I_1-100 % ET_{crop}, I_2-80 % ET_{crop}, I_3-60 % ET_{crop}) and sub plot treatments were two fertigation levels *viz.*, F_1-100 per cent RDF through drip (WSF), F_2-80 per cent RDF through drip (WSF). There were two controls (check basin) with manual application of recommended dose of fertilizer (C_1) and without fertilizer (C_2) in combination of surface irrigation at 1.0 IW/CPE ratio, respectively which kept separated beside main and submain treatments. The transplanting was done for three different spacing *i.e.* S_1 75x75cm, S_2 75-50x90cm, S_3 175-50x50cm in case of drip irrigation system and 75x75cm in case of check basin to maintain uniform plant population per hectare. For the experimental treatments fertigation was given in three split doses. The N, P and K were given at interval of 30, 60 and 90 DAT through 19:19:19 grade and remaining quantity of N was given through urea by calculating the quantity of fertilizer. For control C_1 (100 % RDF through soil application) 1/3rd quantity of N and 100 per cent P, K was applied as a basal dose and remaining 2/3rd quantity of N was applied at 30, 60 and 90 DAT through manual application of solid fertilizers *viz.*, urea, SSP and MOP. For control C_2 (surface irrigation with 1.0 IW/CPE ratio) no fertilizer was given which kept as absolute control. Total yield of each net plot was calculated by summation of weight of fruit per net plot from all pickings. The grand total of each plot was converted on hectare basis (t ha^{-1}).

Irrigation scheduling :

Emission uniformity (EU) :

In finding out emission uniformity of the system, the procedure suggested by Nakayama and Bucks (1986) was used. In this, the laterals of drip system were laid on the ground surface. The catch can were placed below emitters to collect the discharged water. The emitter discharge was determined at head, middle and tail end of lateral. The emitter discharge was used for evaluation of emission uniformity. The formula for estimation of field emission uniformity is presented below :

$$EU_f = \frac{q\,min}{q\,ave} \times 100$$

where,

EU_f = Field emission uniformity

q_{min} = Minimum emitter discharge (lph)

q_{ave} = Average emitter discharge (lph)

Irrigation scheduling for check basin :

For check basin, irrigation was applied to the crop with depth of 5 cm, IW/CPE=1.0

Irrigation scheduling for drip irrigation system :

The irrigation was scheduled based on pan evaporation data with interval of alternate day. The CPE was calculated by summation of pan evaporation of previous 2/3 days.

The volume of water applied was, thus, calculated by using following formula :

$$V = Ep \times Kp \times Kc \times A \times Aw$$

where,

V = Volume of water to be applied, lt./alternate day/plot

Ep = Pan evaporation of previous two days, mm

Kp = Pan factor (0.7)

Kc = Stage wise crop co-efficient

A = Area of plot m^2

Aw = Wetted area for brinjal (0.75).

The irrigation requirement was estimated by considering crop co-efficient as per growth stage.

Growth stage	Crop co-efficient	Crop duration
Initial stage	0.3	0-20
Development stage	0.7	20-40
Mid and late season	1.05	40-135

The operation time of drip unit (t) was calculated by the formula as given by (Pawar, 2001) :

$$t = \frac{V}{q \times Ne} \times 60$$

where,

t = Operation time of system (min.)

V = Volume of water to be applied, lt./alternate day/plot

q = Average emitter discharge (lph)

Ne = Number of emitter per plots.

Field water use efficiency (FWUE) :

Field water use efficiency is the ratio of marketable produce of the crop and seasonal water requirement of crop during its period (Michael *et al.*, 1978) :

$$FWUE = \frac{Y\,(kg\,ha^{-1})}{WR(ha - mm)}$$

where,
WUE = Field water use efficiency
Y = Marketable produce (kg ha^{-1})
WR = Seasonal water requirement of crop (ha-mm)

RESEARCH ANALYSIS AND REASONING

The finding of the present study as well as relevant discussion have been presented under the following heads:

Irrigation studies :

Total irrigation water applied :

Water requirement of brinjal (Table 1) was calculated on the basis of volume of water to be applied every 2nd or 3rd days for treatment I_1 (100 % ET_{crop}), I_2 (80 % ET_{crop}), I_3 (60 % ET_{crop}) by considering the area of the plot. Irrigation water supplied for brinjal during entire crop growth period was 85, 28.1, 18.3 and 9.4 ha-cm which was estimated and applied during the period of investigation for C_1 (check basin), I_1 (100 % ET_{crop}), I_2 (80 % ET_{crop}) and I_3 (60 % ET_{crop}), respectively. Seasonal water requirement of brinjal with surface irrigation was 85 ha-cm.

Water saving over surface irrigation :

The treatment wise water requirement (Table 1) was observed to be 85, 28.1, 18.3 and 9.4 ha-cm for C_1 (check basin), I_1 (100 % ET_{crop}), I_2 (80 % ET_{crop}) and I_3 (60 % ET_{crop}), respectively. The treatment wise saving in comparison with the surface irrigation was 66.94, 78.47, and 88.94 per cent in the treatments I_1 (100 % ET_{crop}), I_2 (80 % ET_{crop}) and I_3 (60 % ET_{crop}), respectively. Similar kind of results have been reported by Sivanappan and Padmakumari (1980), Baldota and Bhatane (1983), Satpute and Bendale (1985), Gorantiwar *et al.* (1987), Yadav *et al.* (1993), Patil (1999), Karthikeyan (2000), Singandhupe *et al.* (2000), Ekad (2003), Raskar (2003) and Gutal *et al.* (2005).

Field water use efficiency :

Data pertaining to (Table 1) show that the field water use efficiency (FWUE) was maximum with treatment combination of $S_3I_3F_1$ (Spacing of 175-50 × 50cm with 60 % ET_{crop} and 100 % RDF through drip) *i.e.* 46.91 q ha^{-1}-cm. While the lowest field water use efficiency was reported with control C_2 (check basin with no fertilizer) *i.e.* 1.51 q ha^{-1}-cm. These findings are in agreement with results reported by Firke and Deolankar (2000), Shinde *et al.* (2002) and Tumbare and Bhoite (2002).

Emission uniformity :

Uniform distribution of water to the crop in drip irrigation is important for uniform availability of moisture in the root zone and there by having a uniform growth and development

Table 1 : Seasonal water requirement (ha-cm), water saving over flood irrigation (%), field water use efficiency (q ha^{-1}-cm) as influenced by different treatment combination

Treatment combinations	Seasonal water requirement (ha-cm)	Water saving over flood irrigation (%)	Field water use efficiency (q ha^{-1}-cm)
$S_1I_1F_1$	28.1	66.94	12.38
$S_1I_1F_2$	28.1	66.94	11.15
$S_1I_2F_1$	18.3	78.47	17.76
$S_1I_2F_2$	18.3	78.47	15.79
$S_1I_3F_1$	9.4	88.94	32.41
$S_1I_3F_2$	9.4	88.94	29.12
$S_2I_1F_1$	28.1	66.94	14.90
$S_2I_1F_2$	28.1	66.94	13.55
$S_2I_2F_1$	18.3	78.47	21.59
$S_2I_2F_2$	18.3	78.47	19.58
$S_2I_3F_1$	9.4	88.94	39.35
$S_2I_3F_2$	9.4	88.94	35.88
$S_3I_1F_1$	28.1	66.94	17.73
$S_3I_1F_2$	28.1	66.94	16.08
$S_3I_2F_1$	18.3	78.47	25.48
$S_3I_2F_2$	18.3	78.47	23.22
$S_3I_3F_1$	9.4	88.94	46.91
$S_3I_3F_2$	9.4	88.94	42.99
C_1 (RDF)	85	-	3.14
C_2	85	-	1.51

of crop. The emission uniformity of drip irrigation system was 93.56 per cent which was satisfactory. The discharge of dripper was 4.0 lph.

Conclusion :

The treatment combination of plant spacing of S_3 (175-50 × 50cm) with irrigation level I_3 (60 % ET_{crop}) and fertigation level F_1 [100 % RDF through drip (WSF)] recorded maximum field water use efficiency (FWUE) *i.e.* 46.91 q ha^{-1}-cm over the rest of treatments. Water saving in comparison with the surface irrigation was 66.94, 78.47, and 88.94 per cent in the treatments I_1 (100 % ET_{crop}), I_2 (80 % ET_{crop}) and I_3 (60 % ET_{crop}).

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