

WEED DYNAMICS, YIELD, QUALITY AND ROOT GROWTH OF CAPSICUM UNDER DRIP IRRIGATION AND MULCHING

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ABSTRACT

A field experiment was conducted during 2006-07 and 2007-08 at Precision Farming Development Centre, Horticulture Farm, Indira Gandhi Agricultural University, Raipur, Chhattisgarh, India to evaluate the weed dynamics, yield, quality, organoleptic parameters and root growth of *Capsicum* as influenced by drip irrigation and mulches. The black polythene mulch being at par with paddy straw mulch gave the least weed population, dry weight and highest weed control efficiency over other mulches. Drip irrigation at 0.6 Epan obtained the least value of weed growth and highest weed control efficiency. Drip irrigation at 1.0 Epan showed highest fruit yield (32.02 t ha⁻¹), total soluble solid (5.72), ascorbic acid (120.25 mg 100g⁻¹) and organoleptic parameters but root growth registered maximum in flood irrigation at 1.0 IW/CPE. Black polythene followed by paddy straw mulch showed maximum fruit yield and other parameters. Pungent test scored maximum with flood irrigation at 1.0 IW/CPE and no mulch. Drip irrigation at 1.0 Epan along with black polythene as well as paddy straw mulch restrict weed growth, harvested quality fruit with higher fruit yield of capsicum.

Key words: Capsicum, drip irrigation, mulch, quality, root growth, weed dynamics

INTRODUCTION

Capsicum (*Capsicum annum* L.) is one of the important commercial crops of India. It is a crop of tropical and sub-tropical regions and requires a warm humid climate. It is rich source of vitamin A and C with good medicinal properties. Among the spices consumed per head, dry capsicum fruits constitute a major share. Recently, formulated flavour extracts called 'Capsicum oleoresin' has varied uses in processed food and beverage industries (Dhar and Majumdar, 2006). Capsicum being a long duration crop, maintaining soil moisture and weed free status throughout its growth

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period is crucial for getting higher yield. Under these circumstances, drip irrigation along with mulching are good approaches for efficient means of applying water and maintaining weed free condition. In drip irrigation, water is applied directly to root zone around the plants through a pipe network with the help of emitters near the plants. Thereby conveyance and distribution losses of water could be minimized substantially. Although drip irrigation requires higher initial installation cost, but due to its major advantages such as high benefit cost ratio, minimum disease and pest incidence and saving energy and labour, compensate its higher initial cost (Choudhary *et al.*, 2006 and Ertek *et al.*, 2007). Mulching conserve soil moisture through less evaporation losses and also improve the soil properties, thereby produce better fruit quality with less weeds, disease and pest etc. (Samedani and Rahimian, 2006). The present study was carried out to study the weed dynamics, root growth and quality, organoleptic parameters and yield of capsicum under drip irrigation and mulches.

MATERIALS AND METHODS

A field study was conducted at Precision Farming Development Centre, Horticulture Farm, Indira Gandhi Agricultural University, Raipur (India) during 2006-07 and 2007-08. The experimental site receives an average annual rainfall of 1200-1400 mm and most of which (about 85%) is concentrated from third week of June to mid September and little during October and February. The soil of the experimental site was silty clay loam, neutral in reaction (pH 7.06), medium in organic carbon (0.49%), low in available nitrogen (236.5 kg ha⁻¹), medium in available P (18.8 kg ha⁻¹), high in available K (310.5 kg ha⁻¹) and normal in EC (0.42 dS m⁻¹ at 25 °C). Capsicum (var. *Agnirekha*) was taken as test crop during study. The experiment was laid out in split plot design with three replications. Four irrigation levels [i.e. L₁: 1.0 Epan (pan evaporation) through drip, L₂: 0.8 Epan through drip, L₃: 0.6 Epan through drip and L₄: 1.0 IW/CPE through flood irrigation (FI)] were allotted to main plots and four mulching treatments i.e. M₁: No mulch along with glyphosate @ 6.0 ml l⁻¹ with 600 l ha⁻¹ of water followed by 2 hand weeding at 26 and 51 DAP, M₂: Black polythene mulch (BPM; 40 µ thickness), M₃: Transparent polythene mulch (TPM; 40 µ thickness), M₄: Paddy straw mulch (PSM; 5 t ha⁻¹) were allotted to sub-plots. Seedlings were raised in a nursery and after preparing the main field, 35 days old seedlings were transplanted on 1st October, 2006 and 3rd October, 2007, respectively with the gross plot area of 4.80 m x 5.40 m (25.9 m²) and net area of 2.40 m x 4.50 m (10.8 m²). The capsicum crop was nourished with fertilizer dressing @ 180 kg N, 120 kg P and 120 kg K ha⁻¹. Nitrogen was applied in three split doses i.e. 50% at basal, 25% at 30 DAT and rest 25% at 50 DAT and entire quantity of phosphorus along with potash was applied as basal dose and thoroughly mixed in soil. Spacing (60 cm x 45 cm) was maintained as per recommendation. All other cultural practices were done as per standard recommendation for capsicum. Drip laterals were placed on 8th DAP (days after planting) and started imposing the allotted treatments from 10 DAP. Mulches were placed on the planted bed carefully 12 DAP

as per the quantity given in treatments. Glyphosate @ 6.0 ml l⁻¹ was sprayed 26 DAP for both the years by using flat nozzle with the help of using card board above nozzle to protect the drift hazards. The total water used ranges from 334.6 to 531.8 mm during 2006-07 and 311.1 to 510.2 mm during 2007-08. Cost of mulch was Rs 65 kg⁻¹ (1USD equivalent to 45 Rs) and Rs 400/ha/irrigation charge for water. Flood irrigation required 15 irrigations throughout the crop period. There were six picking of capsicum fruits which started from 20th and 22nd January during 2007 and 2008 respectively and final harvests were done on 11th and 12th March during 2007 and 2008 respectively.

Weed parameters (weed density, weed dry weight, weed control efficiency and weed index) were recorded during critical competition period (25, 50 and 75 DAP), fruit yield was recorded as per picking and cumulative has been used for drawing final yield. Quality parameters like total soluble solids (TSS), ascorbic acid and capsaicin were measured. Besides, root growth parameters (i.e. maximum root length, root numbers, root volume, root dry weight, root density and root fractions) and organoleptic parameters (i.e. appearance, colour, shining, juiciness and pungency) were measured. Statistical analysis was carried out using standard agricultural statistical package (AGRES).

RESULTS AND DISCUSSION

Weed dynamics

Among the dominant weed species observed in experimental field, *Cyperus rotundus* was the only sedge, *Echinochloa colona*, *Cynodon dactylon* and *Brachiaria ramosa* were major grasses and *Parthenium hysterophorus*, *Physalis minima*, *Melilotus alba*, *Chenopodium album*, *Convolvulus arvensis* were the major broad leaves weeds.

Weed density and weed dry weight

Weed density and weed dry weight were minimum with drip irrigation at 0.6 Epan followed by drip irrigation at 0.8 Epan at different days after planting. However, flood irrigation at 1.0 IW/CPE registered maximum value of weed density and weed dry weight (Table 1). These might be due to the restricted wetting area near the plant parts in drip irrigated plants. The density and dry weights were more because flood irrigation induces the weed seeds to germinate and emerge quickly. Among the mulches, black polythene mulch recorded the minimum weed density and weed dry weight throughout the crop growth period. However, the maximum weed density and weed dry biomass throughout the crop growth period were observed with no mulch. It was also noticed that transparent polythene mulch induces *Echinochloa colona* and *Cynodon dactylon* grasses to emerge quickly over others. It might be due to the fact that the grasses are having the higher photosynthetic efficiency and can absorb even long wave radiation which was emitted from the soil. Most of the inferior quality of radiations was filtered by transparent polythene and only good

quality radiation was transmitted through the polythene (Orzolek, 1995). But sedges and broadleaves were more with no mulch having profuse canopy coverage and high competing ability. The growth of weeds was less in paddy straw mulch followed by black polythene mulch. Weeds emerged only near the plants where holes were made on black polythene mulch, whereas in paddy straw mulch weeds emerged in the area where solar radiation was penetrated. It might be due to the unavailability of solar radiation which restricts the weed seeds to germinate and emerge as black polythene mulch completely restricts the penetration of light to soil, whereas paddy straw mulch allows restricted penetration of solar radiation by zigzag motion.

Weed control efficiency

Drip irrigation at 0.6 Epan obtained 51.2% weed control efficiency (WCE) followed by 0.8 and 1.0 Epan (45.3 and 38.1% respectively); whereas, the lowest WCE was recorded with flood irrigation at 1.0 IW/CPE (Table 1). Flood irrigation induces the weed seeds of seed bank to germinate and provide congenial condition for further growth from entire area. Drip irrigation generally suppress the weed seeds to germinate; whereas, wet region favours the weeds growth. Among the different mulches, black polythene mulch had maximum WCE (72.9%) followed by paddy straw mulch (32.9%). Maximum weeds were found in no mulch followed by transparent polythene mulch. Lesser weed germination and infestation by restricting the penetration of solar radiation under black polythene mulch resulted in higher weed control efficiency. Transparent polythene mulch induced the germination of grasses therefore WCE was comparatively lower (Patel *et al.*, 2009).

Weed Index

The weed index was maximum in flood irrigation at 1.0 IW/CPE (36.0) followed by drip irrigation at 0.6 Epan (20.2). The maximum weed index (27.8) was recorded from no mulch followed by transparent polythene mulch and paddy straw mulch (20.7 and 5.9 respectively).

Fruit yields

Drip irrigation at 1.0 Epan recorded the highest capsicum yield (32.02 t ha^{-1}) which was statistically at par with drip irrigation at 0.8 Epan (29.90 t ha^{-1}). However, flood irrigation at 1.0 IW/CPE had the lowest yield (20.52 t ha^{-1}). Black polythene mulch recorded maximum yield (31.24 t ha^{-1}) followed by paddy straw mulch (29.40 t ha^{-1}). Lowest yield was obtained from no mulch followed by transparent polythene mulch (22.56 and 24.77 t ha^{-1} respectively).

Drip irrigation at 1.0 and 0.8 Epan supplied water drop by drop with slow flow rate which restricted the water losses and allowed the plants to absorb available soil moisture from the root zone and thereby increased the productivity of capsicum. Flood irrigation at 1.0 IW/CPE had reduced the capsicum yield by 56.12, 45.73 and 24.52% compared to drip irrigation at 1.0, 0.8 and 0.6 Epan respectively (Table 2). Under flood irrigation at 1.0 IW/CPE most of the applied water was lost through

evaporation and leaching due to fast rate of application. This also favoured to grow more weeds and competed with the capsicum crop for nutrient and moisture, which directly reduced the capsicum yield. Capsicum yield showed inverse linear relationship with weed dry weight ($R^2=0.60$). Similarly, Choudhary *et al.*, (2006) also reported that under flood irrigation, the crop experienced excess moisture (water stagnation) conditions in the beginning, which enhanced the leaching of available nutrients. The crop was under favourable condition only for a short span of time and due to high evaporation rate from soil surface most of the water was lost and at the end of the irrigation cycle, availability of moisture became insufficient, which created water stress.

Placement of black polythene mulch registered 6.25, 26.12 and 28.48% higher yield of capsicum, than paddy straw mulch, transparent polythene mulch and no mulch, respectively. Vos and Sumarni (1997) also reported that crop under black polythene mulch and paddy straw mulch had higher chlorophyll content which enhances the carbon dioxide and other gasses exchange and ultimately leads to higher photosynthesis and transpiration. Therefore, dry matter accumulation and partitioning was better at different plant parts and enhanced crop growth parameters and capsicum yield than other mulches.

Quality parameters

Flood irrigation of capsicum at 1.0 IW/CPE recorded maximum total soluble solids (5.72%) followed by drip irrigation at 0.6 Epan (5.39%). Capsicin showed highest values in drip irrigation at 1.0 Epan (0.40%). However, TSS and capsicin values were lower with drip irrigation at 1.0 Epan (4.16 and 0.26% respectively) followed by drip at 0.8 Epan (Table 2). In contrary, ascorbic acid content was higher with drip irrigation at 1.0 Epan (121.27 mg 100g⁻¹) followed by drip irrigation at 0.8 Epan (118.63 mg 100g⁻¹) and least values under flood irrigation at 1.0 IW/CPE followed by drip at 0.6 Epan. Black polythene mulch (4.50 and 0.29% respectively) and paddy straw mulch (4.60 and 0.30% respectively) had lower TSS and capsicin. Maximum TSS and capsicin were measured with no mulch followed by transparent polythene mulch. In contrary ascorbic acid was maximum with black polythene mulch (119.92 mg 100g⁻¹) followed by paddy straw mulch and least with no mulch (108.99 mg 100g⁻¹) followed by transparent polythene mulch (Table 2). Yield was inversely linearly related with TSS and capsicin ($R^2= 0.93$), whereas, positive linear relationship ($R^2=0.98$) was observed with ascorbic acid content (Figure. 2 a, b, c).

Higher TSS and capsicin with flood irrigation at 1.0 IW/CPE and no mulch is due to high accumulation of soluble solids which helps plant not to loose water from their fruits to sustain against stresses. The increased amount of capsicin content of fruit could be attributed to the increased cell metabolism, enzymatic activity and mineral composition (Dhar and Majumdar, 2006). In black polythene mulch and drip irrigation at higher levels, the availability of water and nutrients were better. Similarly, with paddy straw mulch the activity of microbes might have increased with

decomposition of it, which in turn increases inavailability of nutrients. Higher microbial activity leads to secretion and formation of organic acid which was directly up taken by plants and this leads to higher ascorbic acid (Mahendaren and Bandara, 2000).

Root growth

Flood irrigation at 1.0 IW/CPE showed maximum root length, root number, root volume and root dry weight at 120 DAP (30.89 cm, 29.41, 26.69 cm³ and 11.62 g respectively) followed by drip irrigation at 0.6 Epan (29.25 cm, 26.16, 24.28 cm³ and 10.26 g respectively). Whereas, low value of all root growth parameters were recorded in drip irrigation at 1.0 Epan followed by 0.8 Epan (Table 3) which might be due to low availability of water with flood irrigation at 1.0 IW/CPE. Crop plants suffered from adverse condition during first 1-3 days of irrigation cycle due to suffocation and stress at the end of irrigation cycle. The unavailability of water helps the plant roots to grow still deeper thereby most of the photosynthates were translocated towards the roots and these were further utilized for growth and development. It was also noticed that with flood irrigation at 1.0 IW/CPE, roots were more fibrous and branched. When photosynthates were translocated towards roots and again partitioned according to need of the plants. Most of the photosynthates were translocated and burned to produce fibrous roots and rest was used for normal growth and development (Sahu, 2003 and Choudhary, 2005-06). No mulch recorded maximum root length, root number, root volume and root dry weight (30.74 cm, 28.01, 25.99 cm³ and 11.06 g respectively) followed by transparent polythene mulch. Poor root growth parameters were observed with black polythene mulch followed by paddy straw mulch (Table 3). This was mainly due to low availability of water for crop plants in above cited two treatments. There was more competition for water among crop plants and weeds and rate of evaporation was also higher in no mulch because of completely exposed area. However, with black polythene mulch and paddy straw mulch the loss of water was very meager due to less exposed area and low weed density. These led to uptake water by plant for longer time with sufficient quantity therefore the development of root was near the surface of ground. Yield was inversely linearly related with root dry weight ($R^2=0.98$) (Figure. 2d).

Root density was not consistent with irrigation levels and mulches. Maximum root fraction was observed on top soil with drip irrigation at 1.0 Epan (47.0%) followed by drip irrigation at 0.8 and 0.6 Epan (Figure. 3). But comparatively higher root fraction was recorded with drip irrigation at 0.6 Epan on deeper soil over upper soil (11.8%) and vice versa on higher level of drip irrigation (2.0%). However, flood irrigation at 1.0 IW/CPE had more root fraction at lower layer than upper layer which was contrary to drip irrigation levels. Comparatively higher root fraction was also noticed at more distances from plant, than near the plant with flood irrigation at 1.0 IW/CPE. Maximum root canopy was noticed with flood irrigation at 1.0 IW/CPE over other drip irrigation levels. Black polythene mulch and paddy straw mulch had

shallow root depth near the plant (Figure 1). This was mainly due to availability of enough moisture on surface soil which restricts the excessive growth of roots. However, no mulch and transparent polythene mulch showed different root behavior.

Organoleptic parameters

Drip irrigation at 1.0 Epan secured maximum score with respect to appearance, colour, shining and juiciness of green capsicum over other drip irrigation levels at 0.8 and 0.6 Epan. However, the least score was recorded with flood irrigation at 1.0 IW/CPE. But, shining score was least with drip irrigation at 0.6 Epan. On the other hand, flood irrigation at 1.0 IW/CPE secured the higher score for pungency over others. Similar finding was also reported by Choudhary *et al.*, (2006). Black polythene mulch secured the highest score of appearance, colour and juiciness over others. However, the least score was secured by crop with no mulch. Whereas, shining score was high with transparent polythene mulch and least with paddy straw mulch. On contrary, juiciness was least scored with transparent polythene mulch. Pungency scored high with no mulch and least with black polythene mulch (Table 4).

However, the interaction between drip irrigation levels and mulches were not statistically significant.

CONCLUSION

Use of drip irrigation at 1.0 Epan registered the higher fruit yield of capsicum along with better quality. But drip irrigation at 0.8 Epan had equally good to drip irrigation at 1.0 Epan. During the study capsicum used the total water from 311.1 to 531.8 mm. However, among the mulches black polythene as well as paddy straw mulch restricts the weed growth and harvested quality capsicum with higher fruit yield. Therefore, as per availability of irrigation water and mulches could be used to harvest better quality capsicum with higher fruit yield.

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Table 1. Weed density, weed dry weight, weed control efficiency and weed index as influenced by drip irrigation and mulches in capsicum (pooled data of 2 years)

Treatment	Weed density (no. m ⁻²)			Weed dry weight (g m ⁻²)			Weed control efficiency (%)	Weed index
	25 DAP	50 DAP	75 DAP	25 DAP	50 DAP	75 DAP		
<i>Drip irrigation level</i>								
1.0 Epan	34.8(5.94)	26.4(5.19)	43.6(6.64)	11.82(3.51)	8.51(3.00)	15.91(4.05)	38.1	-
0.8 Epan	31.6(5.66)	22.7(4.81)	41.1(6.45)	10.42(3.30)	7.74(2.87)	13.90(3.79)	45.3	6.7
0.6 Epan	28.3(5.37)	19.6(4.48)	37.9(6.19)	9.31(3.13)	6.79(2.70)	12.41(3.59)	51.2	20.2
FI (1.0 IW/CPE)	38.2(6.22)	30.6(5.58)	46.7(6.87)	18.16(4.32)	16.27(4.09)	23.53(4.90)	-	36.0
CD P=0.05)	3.0	2.1	2.9	1.36	1.33	2.66		
<i>Mulching</i>								
NM	44.8(6.73)	34.6(5.93)	54.8(7.44)	19.12(4.43)	13.85(3.79)	23.83(4.93)	-	27.8
BPM	10.6(3.33)	7.7(2.87)	14.1(3.83)	5.10(2.36)	3.91(2.10)	6.16(2.58)	72.9	-
TPM	41.8(6.50)	31.9(5.70)	52.9(7.31)	13.72(3.77)	11.61(3.48)	19.36(4.46)	21.5	20.7
PSM	35.7(6.01)	25.0(5.05)	47.4(6.92)	11.78(3.50)	9.92(3.23)	16.38(4.11)	32.9	5.9
CD (P=0.05)	3.1	2.8	3.60	1.54	1.78	2.87		

FI: Flood irrigation; BPM: Black polythene mulch; TPM: Transparent polythene mulch; PSM: Paddy straw mulch; DAP: days after planting; Figures in parenthesis are square root transformed values $\sqrt{x + 0.5}$

Table 2. Fruit yield, total soluble solid, ascorbic acid and capsicin as influenced by drip irrigation and mulches in capsicum (pooled data of 2 years)

Treatment	Fruit yield (t ha ⁻¹)	TSS (%)	Ascorbic acid (mg 100g ⁻¹)	Capsicin (%)
<i>Drip irrigation level</i>				
1.0 Epan	32.02	4.16	121.27	0.26
0.8 Epan	29.90	4.61	118.63	0.30
0.6 Epan	25.54	5.39	113.00	0.33
FI (1.0 IW/CPE)	20.52	5.72	104.62	0.40
CD (P=0.05)	2.66	0.38	9.79	0.05
<i>Mulching</i>				
No Mulch	22.56	5.45	108.99	0.36
BPM	31.24	4.50	119.92	0.29
TPM	24.77	5.33	111.52	0.34
PSM	29.40	4.60	117.09	0.30
CD (P=0.05)	2.03	0.56	7.90	0.04

FI: Flood irrigation; BPM: Black polythene mulch; TPM: Transparent polythene mulch; PSM: Paddy straw mulch

Table 3. Root growth parameters at 120 DAP as influenced by drip irrigation and mulches in capsicum (pooled data of 2 years)

Treatment	Root number plant ⁻¹	Root length (cm)	Root dry weight (g plant ⁻¹)	Root volume (cm ³)	Root density (g cm ⁻³)
<i>Drip irrigation level</i>					
1.0 Epan	23.01	27.46	8.80	22.07	0.41
0.8 Epan	23.71	27.94	9.54	23.38	0.42
0.6 Epan	26.16	29.25	10.26	24.28	0.43
FI (1.0 IW/CPE)	29.41	30.89	11.62	26.69	0.44
CD (P=0.05)	1.65	2.12	0.74	2.05	NS
<i>Mulching</i>					
NM	28.01	30.74	11.06	0.51	0.43
BPM	23.18	27.17	9.06	0.49	0.41
TPM	26.98	29.71	10.50	0.53	0.43
PSM	24.11	27.93	9.60	0.50	0.42
CD (P=0.05)	2.82	2.61	1.08	NS	NS

FI: Flood irrigation; BPM: Black polythene mulch; TPM: Transparent polythene mulch; PSM: Paddy straw mulch; DAP: days after planting

Table 4. Scores of organoleptic parameters as influenced by drip irrigation and mulches in capsicum (pooled data of 2 years)

Treatment	Appearance	Colour	Shining	Juiciness	Pungency
<i>Drip irrigation level</i>					
1.0 Epan	3.92	4.36	3.49	4.36	2.04
0.8 Epan	3.67	4.04	3.15	4.03	2.26
0.6 Epan	3.3	3.31	2.64	3.28	2.87
FI (1.0 IW/CPE)	2.83	2.98	2.68	2.95	3.28
CD (P=0.05)	0.32	0.2	0.38	0.18	0.48
<i>Mulching</i>					
NM	2.96	3.39	3.2	3.37	3.04
BPM	3.91	4.04	2.66	4.02	2.19
TPM	3.04	3.31	3.54	3.29	2.95
PSM	3.8	3.95	2.56	3.94	2.29
CD (P=0.05)	0.38	0.4	0.37	0.41	0.53

FI: Flood irrigation; BPM: Black polythene mulch; TPM: Transparent polythene mulch; PSM: Paddy straw mulch; Score: 1: poor; 2: fair; 3: good; 4: very good; 5: excellent

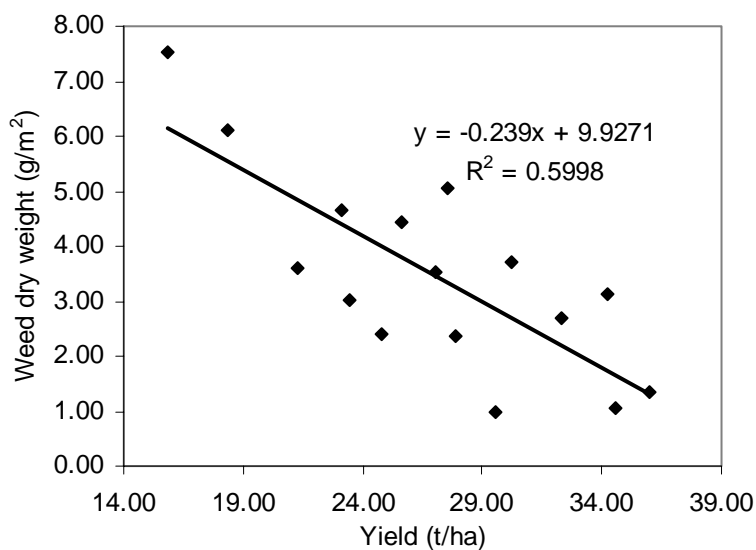


Figure 1. Relationship between yield and weed dry weight as influenced by drip irrigation and mulches in capsicum

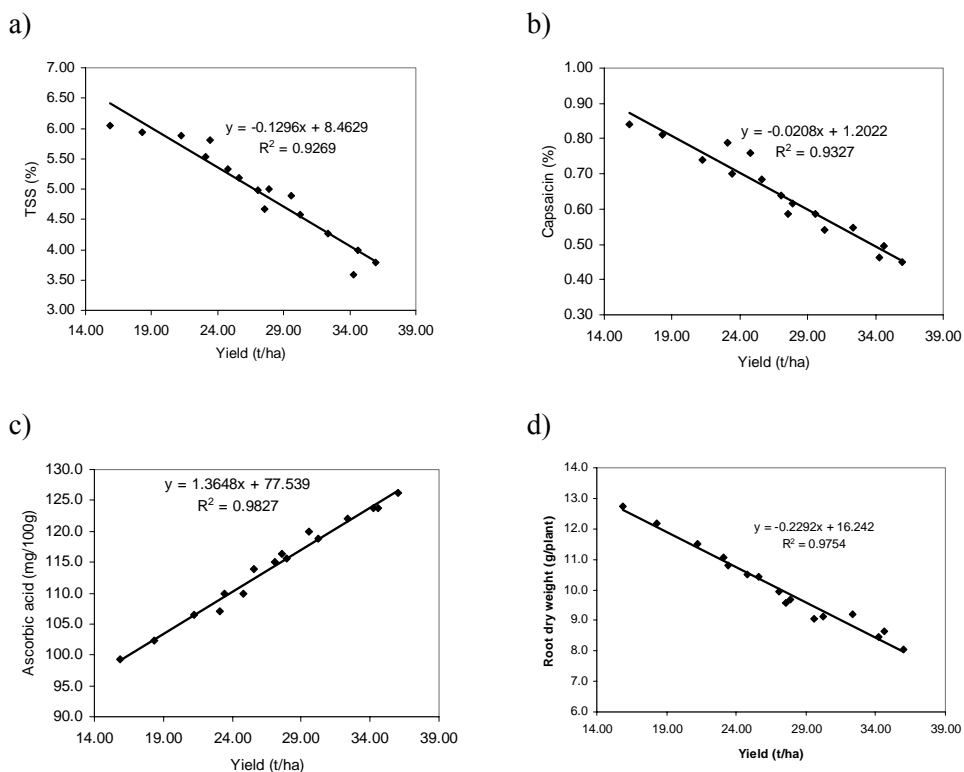
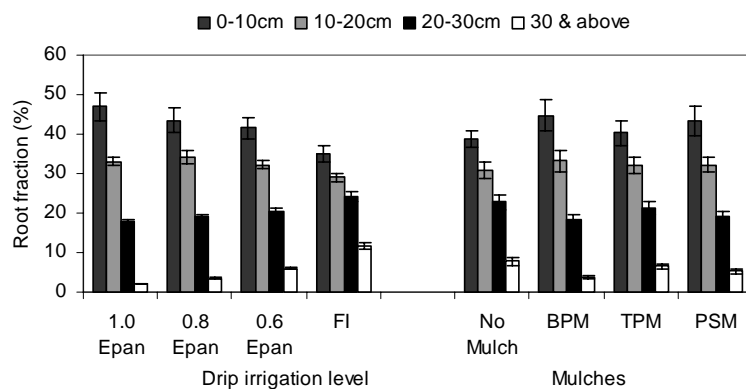


Figure 2. Relationship of yield with a) TSS, b) capsicin, c) ascorbic acid and d) root dry weight as influenced by drip irrigation and mulches in capsicum



FI: Flood irrigation at 1.0 IW/CPE; BPM: Black polythene mulch; TPM: Transparent polythene mulch; PSM: Paddy straw mulch

Figure 3. Root fractions as influenced by drip irrigation and mulches in capsicum (error bars shows the mean \pm standard deviation)