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Effect of irrigation methods and mulching on growth and yield parameters of chilli (*Capsicum annum* L.) in arid condition

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Abstract

The research work was carried out to study the impact of various irrigation methods and mulching on plant growth, production and profitability of chilli *cv.* R.Ch. 1 at Agricultural Research Station, Mandor, Jodhpur during July, 2016 to February, 2017. The results of surface irrigation were compared with drip irrigation system under no mulch and in conjunction with plastic mulch. The results revealed that the crop was irrigated by drip irrigation on raise bed with 100 micron Linear Low Density Poly Ethylene plastic mulch (T₈ treatment) exhibited significantly higher seedling survival at 15 and 30 days after transplanting (95.16% and 91.70%), highest plant height (47.10 cm at 45 DAT and 54.60 cm at harvest), highest number of branches (14.93) plant⁻¹, maximum stem girth (2.32 cm) number of roots plant⁻¹ (138.5), highest fruit set (38.47%), length of fresh fruit (12.56 cm), diameter of fruit (3.52 cm) and fresh weight of fruit⁻¹ (8.42g) was observed. The maximum number of fruits plant⁻¹ (125), highest yield plant⁻¹ (1052.5g), yield ha⁻¹ (337.63q) and premier fruit quality score (9.11) with maximum net return (Rs.326407.28) and benefit: cost ratio (3.41) was also reported in same treatment. Comparatively minimum time (15 hours) required for one hectare irrigation was also reported in drip irrigation on raise bed with plastic mulch. This led to lower population of white fly plant⁻¹ (4.53), minimum weed infestation (1.53 weed m⁻²), leaf curl (5.50%) and fruit rot (5.0%) incidence than other treatment combinations. The minimum growth, yield and profitability were reported in check basin method of irrigation without mulch (T₁ treatment).

Keywords: *Capsicum annum*, Day After Transplanting, leaf curl, surface irrigation, survival

Chilli (*Capsicum annum* L.) is an important commercial vegetable cum spice crop of India belongs to the family Solanaceae. The production of chilli crop is affected adversely by moisture deficit. Productivity of the crop can be increased by adopting improved package of practices, particularly *in-situ* moisture

conservation by mulching as well as high-tech irrigation especially drip irrigation with appropriate irrigation scheduling. Use of soil cover and mulching is also known to be beneficial chiefly through their influence on soil moisture conservation, solarization and control of weeds. Beneficial response of plants

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to mulch includes early production, more yield and reduced insect and disease problems (Pattanaik *et al.* 2003). Linear Low Density Poly Ethylene (LLDPE) plastic films have been proved as better mulch because of their puncture resistance quality, thinness and lower cost (Panda 2004). Numerous experiments have reported the benefits of LLDPE mulch in several crops, but research is limited on response of chilli production in western Rajasthan by this method. Keeping this in background, the present study was undertaken to study the effect of different irrigation methods and mulching on chilli crop and compare the result with the conventional method of growing the crop under surface irrigation without mulch.

A field experiment was conducted at Agricultural Research Station, Mandor, Jodhpur (Rajasthan), India during *kharif* seasons of year 2016-17. The soil of experimental plot was of sandy loam texture with average pH range 8.5, having organic carbon 0.55%, available N 180 kg ha⁻¹, P 27.5 kg ha⁻¹ and K 250.0 kg ha⁻¹ during experimentation. The experiment was conducted in a completely randomized design having nine treatments comprising by different irrigation methods and mulching *viz.*, T₁ = Check basin method, T₂ = furrow irrigation method, T₃ = Raise bed with trench method, T₄ = Flat bed with drip irrigation, T₅ = Flat bed + plastic mulch + drip irrigation, T₆ = Raise bed with drip irrigation, T₇ = Raise bed + organic mulch + drip irrigation, T₈ = Raise bed + plastic mulch + drip irrigation, T₉ = Sprinkler irrigation method. In well prepared field, transplanting of Chilli seedlings variety RCh 1 of 35-40 days old were planted in pair row method with a spacing of 45cm x 45 cm/90 cm (33,333 plant ha⁻¹) during last week of June. In check basin and sprinkler system of irrigation the bed size is 2 x 2 meter and in all other methods is 1 x 4 meters. The cultural practices of the crop were followed as per the recommendations. The organic material and LLDPE silver colour film of 100-micron thickness was used for mulching around the plant. The lateral lines of 12 mm diameter LLDPE pipes were laid along with crop rows.

The laterals were provided with inlet drippers of 8 litre hr⁻¹ discharge capacity. All the observations were taken from five randomly selected plant of each replication throughout the investigation period at appropriate time by adopting standard method for growth, development, fruiting behavior and yield.

Seedling survival per cent (after transplanting in main field at 15 DAT and 30 DAT) was recorded by following formula;

Survival percent = [Total survival transplanted plants / Total transplanted plants] × 100

Plant height (at 45 DAT and at harvesting) was measured from soil surface upto the highest shoot tip by straightening all branches. Stem girth was measured 1 cm from the base of the stem using vernier calliper. Observation of number of branches, days taken to first flower initiation, duration of fruiting period and number of fruit plant⁻¹ was recorded by standard counting method. Number of roots, root length was measured by destructive method of uprooting the plants and taking measurement by standard method. Length of fresh fruits measured by scale and fruit diameter using vernier calliper and expressed in centimeter. Fruit set per cent was recorded by following formula;

Fruit set per cent = [Total number of fruit set plant⁻¹ / Total number of flowers plant⁻¹] × 100

Fruit weight was determined by weighing method at the time of harvesting and expressed in gram fruit⁻¹. The total fruit yield plant⁻¹ and hectare⁻¹ was calculated by weighing total marketable fruits and has been expressed in gram and quintal respectively. Further, the net return was calculated by subtracting cost of each treatment from gross return. The gross return was calculated from yield multiplied by average market rate during the period of investigation. The benefit cost ratio was calculated by dividing net return to total cost of cultivation. Benefit-Cost ratio and net profit were carried out to determine the economic feasibility of the crop using surface and drip irrigation as suggested by Tiwari *et al.* (1998a).

The seasonal system cost of drip irrigation system included depreciation, prevailing bank interest rate, and repair and maintenance cost of the system. The fixed cost of drip irrigation system was determined to be Rs 112,000 ha⁻¹. The useful life of drip system was considered to be 10 years. The system cost was evaluated by distributing the fixed cost of system over life period of drip irrigation set. For calculating depreciation, the life of the drip irrigation set and 10% junk value was considered. The interest was calculated on the average of investment of the drip irrigation set taking into consideration the value of the set in the first and last year @10% per annum. Cost of repairs and maintenance of set is @2% of initial cost of the drip irrigation set per year. The cost of cultivation includes expenses incurred in land preparation, interculture operation, fertilizer, crop protection measures, irrigation water and harvesting with labour charges. Therefore, total seasonal cost was worked as: depreciation, interest, repairs and maintenance cost of set + cost of cultivation + cost of mulch. The income from produce was calculated using prevailing average market price of capsicum @ Rs 1250 q⁻¹. Disease incidence (leaf curl and fruit rot) and quality of fruits was measured by visual inspection (Five member team of crop experts and plant pathologist). White fly population plant⁻¹ and weed infestation meter⁻² was calculate by simple counting method. The time required for irrigation was calculated as per actual required time of irrigation of specified area by different methods of irrigation. To test the significance of variance of data obtained from crop growth, yield and economics of variance technique for completely randomized design was done by standard procedure prescribed by Panse & Sukhatme (1985). Significance of difference among the treatments effect was tested by 'F' test and critical difference (CD) was calculated, wherever the results were significant.

The results revealed that, the irrigation methods and mulching are significantly influenced growth attributes at all the growth stages (Table 1). The maximum seedling survival per

cent at 15 DAT (95.10%) and 30 DAT (91.70%) was recorded in T₈ treatment, which was significantly superior to other treatment but at par with T₆, and T₇ treatments. The maximum survival per cent of seedling in T₈ treatment might be due to more favourable moisture condition for seedling transplanting and re-establishment of roots than others. The height of plant under treatment T₈ (47.10 cm at 45 DAT) and treatment T₆ (62.60 cm at harvest) was found highest among all other treatments and is 67.19% and 13.40% higher than the T₁ treatment. About to number of branch plant⁻¹, maximum value was recorded in treatment T₈ (14.93) followed by treatment T₇ (12.53) and the lowest value was in treatment T₁ (7.17). Maximum stem girth at harvest (2.36 cm) and highest number of roots plant⁻¹ (138.50) were observed in T₈ treatment whereas longest root system (10.50 cm) was observed in T₃ treatment. The minimum stem girth (1.68 cm) and the number of roots plant⁻¹ (53.57) were observed in T₁ treatment whereas shortest root system (7.97 cm) was observed in T₉ treatment. The higher available moisture status in soil favourably influences the uptake of nutrients which maintains the cell turgidity, cell elongation, photosynthesis and respiration at optimum level, leading to favourable growth and development of plant in terms of plant height, number of branches plant⁻¹, stem girth and number of root plant⁻¹ in the present study. The highest increase in vegetative growth in drip irrigation with mulching might be due to the availability of soil moisture as well as favourable temperature at optimum level for plant growth development (Pattanaik *et al.* 2003; Paul *et al.* 2013). The lowest value of vegetative growth in T₁ might be because of unfavourable moisture regime (moisture stress or excess moisture) in the soil through surface irrigation and competition of weeds for nutrients (Pattanaik *et al.* 2003; Agrawal & Agrawal 2005). The increased growth attributes might have supplied water and nutrients in adequate proportion, which resulted in triggering the production of plant growth hormone, *viz.*, indole acetic acid (IAA) and

Table 1. Effect of different irrigation methods and mulching on vegetative parameter of chilli

Treatments	Seedling survival %		Plant height (cm)		Average number of branches plant ⁻¹	Stem girth at harvest (cm)	Length of root (cm)	No. of roots plant ⁻¹
	15 DAT	30 DAT	45 DAT	At harvest				
T ₁	78.17	73.93	28.17	55.20	7.17	1.68	9.50	53.57
T ₂	82.37	79.23	29.07	57.30	8.07	1.86	10.00	69.77
T ₃	86.97	83.83	32.07	61.70	8.27	1.88	10.50	78.37
T ₄	88.40	84.73	34.03	61.55	9.48	2.26	8.53	102.50
T ₅	90.10	86.33	38.53	61.70	10.28	2.33	8.03	108.70
T ₆	92.50	89.33	40.43	62.60	9.98	2.32	9.03	119.00
T ₇	93.40	90.90	41.97	53.20	12.53	2.30	8.97	135.70
T ₈	95.10	91.70	47.10	54.60	14.93	2.36	8.47	138.50
T ₉	85.20	80.10	34.90	56.70	9.73	2.00	7.97	110.10
S.Em. +	1.646	1.539	2.173	1.859	0.442	0.088	0.228	1.300
CD (P<0.05)	4.871	4.556	6.432	5.504	1.327	0.260	0.675	3.848

higher number of leaves and roots throughout the cropping period (Sankar *et al.* 2008).

The drip irrigation in combination with mulch significantly increased the yield of chilli as compared to drip irrigation without mulch (Table 2) and surface irrigation methods. The minimum days (42.38) required for first flower initiation was reported in T₉ treatment whereas the maximum days (51.39) was required in T₅ treatment. Among various treatments, highest fruit set (38.47%), length of fresh fruit (12.56 cm), diameter of fruit (3.52 cm), duration of fruiting (71.38 days), fresh weight of fruit⁻¹ (8.42 g), maximum number of fruits plant⁻¹ (125), highest yield plant⁻¹ (1052.5 g) and yield ha⁻¹ (337.63 q) was recorded under T₈ treatment, whereas lowest yield (153.45 q ha⁻¹) was recorded under T₁ treatment. This might be due to water stress during the critical growth period and fruit development stage coupled with aeration problem in first few days immediately after irrigation. Another reason to get low yield by surface irrigation without mulch might be due to less availability of nutrients for crop growth due to leaching and

high weed competition between the crops (Pattanaik *et al.* 2003). In drip irrigation system on raise bed with plastic mulch the water is applied at a low rate for a longer period at frequent intervals near the plant root zone through lower pressure delivery system, which increases the availability of nutrients near the root zone with a reduction in leaching losses and minimum weed competition. More nutrient availability, especially near the root zone might have increased the translocation of photosynthetes to storage organ of chilli resulting in an increased weight of fruits. This result corroborated the findings of Singh (2007), Sankar *et al.* (2008), Paul *et al.* (2013) and Kumar *et al.* (2016).

Irrigation methods and mulching also significantly influenced the gross return, net return and benefit cost ratio in chill (Table 3). Maximum net profit of Rs. 326407.28 ha⁻¹ with B: C ratio of 3.41 was recorded in T₈ treatment followed by Rs 296192.61 ha⁻¹ with B: C ratio of 3.11 in T₅ treatment and lowest net profit of Rs 119007.80 ha⁻¹ with a B: C ratio of 1.63 in T₁ treatment (Table 3). It is observed that, the drip

Table 2. Effect of different irrigation methods and mulching on yield and yield attributes of chilli

Treatments	First flower initiation (DAT)	Fruit set %	Length of fresh fruit (cm)	Diameter of fresh fruit (cm)	Duration of fruiting (days)	Weight of single fresh fruit (gm)	No. of fruits plant ⁻¹	Yield plant ⁻¹ (gm)	Yield ha ⁻¹ (q)
T ₁	45.70	17.23	10.75	2.87	52.70	7.63	60.33	460.34	153.45
T ₂	47.70	17.01	11.30	2.75	54.00	7.79	65.33	508.95	169.65
T ₃	47.40	21.31	11.35	2.78	56.10	7.82	68.33	534.37	178.12
T ₄	49.19	27.00	12.01	3.01	62.39	7.97	74.17	591.11	197.03
T ₅	51.39	31.81	12.19	3.14	68.59	8.23	114.17	939.59	313.19
T ₆	49.99	30.89	12.39	3.22	60.39	8.26	89.17	736.52	245.50
T ₇	46.58	36.74	12.30	3.28	66.38	8.36	95.00	794.20	251.53
T ₈	48.38	38.47	12.56	3.52	71.38	8.42	125.00	1052.50	337.63
T ₉	42.38	16.27	11.57	3.10	47.58	7.90	75.00	592.50	184.30
S.Em. +	1.247	1.570	0.201	0.059	1.247	0.133	1.302	9.913	8.257
CD (P<0.05)	3.693	4.649	0.595	0.176	3.693	0.395	3.854	29.337	24.437

irrigation with mulched treatments T₅, T₇ and T₈ gave better net return with higher B: C ratio ha⁻¹ than their corresponding treatments without mulching in conventional irrigation method. The highest net return (US\$ 7098 ha⁻¹), incremental net return (US\$ 1556 ha⁻¹), and incremental benefit-cost ratio (7.03) were found for 50% water application with straw mulch (Biswas *et al.* 2015). The results are in conformity with the findings of Singh (2007), Sankar *et al.* (2008) and Kumar *et al.* (2016). Apart from reducing water consumption, drip irrigation with mulching also helps in reducing cost of cultivation and improving productivity of crops as compared to the same crops cultivated under flood method of irrigation (Paul *et al.* 2013).

Irrigation time significantly pretentious by different irrigation methods. The minimum time required in irrigation (14.50 hours) in T₅ treatment which closely followed by T₈ treatment. Drip irrigation method with or without mulching required less irrigation time than without mulching in conventional irrigation method. There was significant effect

of LLDPE mulch over drip irrigation system alone. Drip irrigation with LLDPE mulching (T₅ & T₈ treatment) saving irrigation time (21.40 hour ha⁻¹ and 21.35 hour ha⁻¹) upto 60 per cent by reducing water losses and increased irrigation efficiency. The increase in water saving per cent in trench method (T₂), drip irrigation system alone (T₄), drip irrigation system with LLDPE mulch (T₅ & T₈), drip irrigation with organic mulch (T₇) and sprinkler system (T₉) over conventional surface irrigation by check basin method (T₁) was 38.8%, 46.6%, 60.0%, 54.4% and 41.9% respectively. The highest water use efficiency of 592 kg ha⁻¹ mm⁻¹ was obtained with 50 per cent water application under polyethylene mulch (Biswas *et al.* 2015). Drip irrigation with mulching helps to achieve yield gains of upto 100 per cent, water savings of upto 40-80 per cent, and associated fertilizer, pesticide, and labour savings over conventional irrigation systems in capsicum crop (Paul *et al.* 2013). Similar trend has been reported in water use efficiency for okra crop by Tiwari *et al.* (1998a) and for tomato crop by Singh (2007).

Table 3. Effect of different irrigation methods and mulching on economics, fruit quality, water saving (%), insect-pest and weed infestation of chilli

Treat-ments	Net Return	B:C ratio	Quality score of fruits	Water saving (%) time (h) for ha ⁻¹ irrigation	No. of white fly plant ⁻¹	Fruit Rot (%)	Leaf curl (%)	Weed Infestation
T ₁	119007.80	1.63	7.24	36.30 (0.0%)	17.43	20.02	15.84	30.03
T ₂	135858.99	1.78	7.46	22.20 (38.8%)	13.73	18.02	12.34	17.43
T ₃	144550.55	1.85	8.04	22.45 (38.2%)	12.43	14.02	10.84	15.53
T ₄	170392.68	2.24	8.00	19.40 (46.6%)	11.60	10.82	9.50	12.40
T ₅	296192.61	3.11	8.50	14.50 (60.0%)	7.90	7.82	7.30	2.10
T ₆	225678.88	2.78	8.20	18.15 (50.0%)	10.40	8.82	8.60	10.10
T ₇	230913.36	2.77	8.50	16.55 (54.4%)	9.53	6.00	8.10	5.73
T ₈	326407.28	3.41	9.11	14.55 (60.0%)	4.53	5.00	5.50	1.53
T ₉	152772.53	1.97	6.50	21.10 (41.9%)	15.43	19.00	13.40	32.18
S.Em. +	0.001	0.005	0.162	1.247	0.346	0.568	0.227	0.394
CD (P<0.05)	0.003	0.017	0.480	3.693	1.026	1.68	0.672	1.166

Occurrence of chilli leaf curling and fruit rot was detected throughout the investigation period. The best performance, with a marked reduction in leaf curling and fruit rot and improve fruit quality was observed in drip irrigation with LLDPE mulching (Table 3). The minimum incidence of fruit rot (5.0%), leaf curling (5.5%) and highest quality score of fruit (9.11) was observed in T₈ treatment which was closely followed by T₇ and T₅ treatments where as maximum incidence of fruit rot (20.02%) and leaf curling (15.84%) was reported in check basin method of irrigation (T₁ treatment) whereas minimum quality score (6.50) was observed in T₉ treatment. Presence of white fly and weed was observed throughout the investigation period. The minimum population of white flies (4.53 plant⁻¹) and weed infestation (1.53 weed m⁻²) was observed in T₈ treatment whereas highest incidence of white flies (17.43 plant⁻¹) and weed infestation (30.03 weed m⁻²) was observed in T₁ treatment. This is due to the fact that in drip irrigation with mulching significantly reduced additional moisture level in field environment which in turn increase quality of fruits and reduce disease infestation,

white fly population as well as it also trim down weed seed germination, growth and development. The increase in quality of fruits was due to the effective utilization of applied nutrients, water and significantly reduced weed growth; disease incidence and increased rate of photosynthesis, sink capacity and accumulated more amounts of dry matter and finally increased quality of fruits and yield. Conventional surface irrigation methods without mulching provide favorable environmental condition for increase insect population and development of disease as well as germinate and develop high density weed plants. The beneficial effect of drip irrigation and black LLDPE mulch in capsicum, tomato and okra was also reported earlier by Horo *et al.* (2003); Singh (2007); Vankar & Shinde (2007), Bhardwaj & Sarolia (2012), Paul *et al.* (2013).

The combination of raised bed + drip irrigation system with LLDPE mulching is observed to be economical and cost effective as compared with conventional surface irrigation without mulching. Thus, the use of drip irrigation system either alone or in combination with

mulching, could increase the chilli yield quality of fruits and profitability. It also reduces white fly population, disease incidence (root rot and leaf curling) and minimise with crop weed competition. Drip irrigation with mulching increase water use efficiency by significant reduction in irrigation time ha⁻¹. It is concluded that the drip irrigation method with LLDPE mulching is suitable for chilli production in arid and semi arid condition of western Rajasthan.

References

- Agrawal N & Agrawal S 2005 Effect of drip irrigation and mulches on the growth and yield of banana *cv.* Dwarf Cavendish. Indian J. Hort. 62: 238–240.
- Biswas S K, Akanda A R, Rahman M S & Hossain M A 2015 Effect of drip irrigation and mulching on yield, water-use efficiency and economics of tomato. Plant Soil Environ. 61: 97–102.
- Bhardwaj R L & Sarolia D K 2012 Effect of mulching on crop production under rainfed condition: A Review. Agri. Rev. 34: 188–197.
- Horo P, Choudhary B M, Prasad B N & Kandeyang S 2003 Effect of micro irrigation on growth and yield of tomato in Jharkhand. The Orissa J. Hort. 31: 80–83.
- Kumar R, Himanshu Trivedi, Rahul Yadav, Bhagwan Das & Ankur Singh Bist 2016 Effect of drip irrigation on yield and water use efficiency on Brinjal (*Solanum melongena*) *cv.* Pant samrat. Int. J. Engg. Sci. Res. Technol. 5: 7–17.
- Panda S C 2004 Mulching. In: Panda S C, Patnaik K K, Mishra J N, Pradhan P C & Alim M A (Eds.), Training Manual on Precision Farming in Horticulture. PFDC, OUAT, Bhubaneswar.
- Panse V G & Sukhatme P V 1985 Statistical Methods for Agricultural Workers. ICAR, New Delhi, pp.63–100.
- Pattanaik S K, Sahu N N, Pradhan P C & Mohanty M K 2003 Response of Banana to drip irrigation under different irrigation designs. J. Agri. Engg. ISAE 40: 29–34.
- Paul J C, Mishra J N, Pradhan P L & Panigrahi B 2013 Effect of drip and surface irrigation on yield, water use efficiency and economics of capsicum (*Capsicum annum* L.) grown under mulch and non-mulch conditions in eastern coastal India. European J. Sustainable Dev. 2: 99–108.
- Sankar V, Lawande K E & Tripathy P C 2008 Effect of micro irrigation on growth, yield and water-use-efficiency of onion (*Allium cepa*) under Western Maharashtra conditions. Indian J. Agri. Sci. 78: 584–588.
- Tiwari K N, Mal P K, Singh R M & Chattopadhyaya A 1998a Response of Okra to drip irrigation under mulch and non-mulch conditions. Agril. Water Manag. 38: 91–102.



Evaluation of stable and non shattering isabgol cultivar - Gujarat isabgol 4

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Abstract

Isabgol growing area was surveyed during 2009-10 and selected genotypes were evaluated in preliminary evaluation trial (PET) during 2010-13 and in large scale varietal trial (LSVT) during 2013-15. It was found that JI-09-21 recorded better growth and yield characters and yield over check Gujarat Isabgol 3. The JI-09-21 did not shatter much even after water dripping and recommended for cultivation as Gujarat Isabgol 4.

Keywords: gujarat isabgol 4, isabgol, new variety, non shattering type

Isabgol (*Plantago ovata* Forsk) is a short duration, more remunerative and medicinally important crop of arid and semiarid regions. In India, it is largely grown in Gujarat, Rajasthan, Madhya Pradesh and Haryana. The area under Isabgol in India during 2014-15 is 1.09 lakh hectares. The production recorded 72 thousand MT with productivity of 660 kg ha⁻¹. In Gujarat, area mostly falls in Banaskantha, Kachchh and Patan districts with acreage of nine thousand hectare with production and productivity 5000 MT and 556 kg ha⁻¹, respectively during 2015-16 (Anonymous 2016a). During the last decade, area and production of isabgol has decreased to the tune of 343% and 281%, respectively, mainly due to problems of seed shattering. At the time of maturity, unseasonal rain or heavy dew leads to failure of the crop which is the fact for reduction of area under Isabgol (Anonymous 2016b). The objective of the study was to evolve non-shattering isabgol cultivars.

Isabgol growing area of Kachchh in Gujarat was surveyed during 2009-10 and subsequently genotypes were evaluated. First three years (2010-11 to 2012-13) 13 genotypes (JI-09-03, 07, 10, 13, 15, 16, 20, 21, 22, 23, 24, 25 and 26) with check (Gujarat Isabgol -03) were evaluated in preliminary evaluation – trial (PET). During 2013-14 and 2014-15, nine genotypes (JI-08-02, JI-09-07, 13, 16, 20, 21, 22, 24 and 25) along with check (Gujarat Isabgol -03) was tested. The trials were carried out at three different locations *viz.*, Jagudan, Kholwada and Deesa in a randomized block design with three replications.

The stability analysis of variance and stability parameters *viz.*, linear regression coefficient (bi) and deviation from regression (S²di) of genotype means over environment were computed as suggested by Eberhart & Russell (1966).

Shattering per cent was computed as suggested by Singh *et al.* (2005) and Chandra (1967). Five

plants in each replication were selected at maturity stage. Entire spike were dipped in water and then observed for seed shattering from selected plants. The percentage of seed shattering calculated by using a following formula.

Shattering per cent = [(Expected seed yield - Seed wt. after threshing) / (Expected seed yield)] × 100

Expected seed yield= H.I. x Sun Dry wt. (kg)/ 100

Considering eight trials at three locations for five years, JI-09-21 was recorded higher (928 kg ha⁻¹) seed yield against 830 kg ha⁻¹ of Gujarat Isabgol 3 (GI 3), which was 11.78% higher than GI-3 (Table 1). The new variety named as

Gujarat Isabgol 4 was having more tillers plant⁻¹ (6.0), more spikes plant⁻¹ (22.7), seeds spike⁻¹ (80.7), higher test weight (1.58 gm) and high swelling factor (11.4 cc g⁻¹) than that of check variety GI-3, due to these yield contributing traits GI-4 is having high seed yield potential (Table 3). The similar kind of results also obtained by Prajapati *et al.* (2011).

Gujarat Isabgol 4 recorded high mean with regression coefficient (bi) near unity and deviation from regression (S²di) around zero for seed yield, indicating GI-4 has average responsiveness and are highly stable over environments (Table 2).

The new culture has compact spike and did not separate easily even after dipping in water. Only 7.25% seeds shattered after dipping in water.

Table 1. The comparative yield performance (kg ha⁻¹) of JI-09-21 (GI 4) over different locations

Year	Trial	Yield (kg ha ⁻¹)		IOC (%)	Rank	S.Em. ±	CD (P<0.05)	C.V. %
		JI-09-21	GI-3					
Jagudan								
2010-11	PET	1014	894	13.42	1/14	56	167	10.80
2011-12	PET	1078	948	13.71	1/14	49	150	10.39
2012-13	PET	907	863	5.10	2/14	51	155	9.47
2013-14	LSVT-II	946	874	8.24	1/10	52	155	11.55
2014-15	LSVT-II	949	812	16.87	1/10	50	148	11.12
	Mean (5)	979	878	11.46	-	-	-	-
Kholwada								
2013-14	LSVT-II	878	769	14.17	1/10	52	154	13.78
2014-15	LSVT-II	852 *	759	12.25	1/10	31	91	9.56
	Mean (2)	865	764	13.22	-	-	-	-
Deesa								
2014-15	LSVT-II	799	722	10.66	3/10	73	215	14.79
Overall Mean (8 trials)....		928	830	11.78	-	-	-	-
Superiority over check....		8/8	-	-	-	-	-	-

Table 2. Stability Analysis for seed yield in Isabgol

Variety	Yi (mean seed yield)(kg plot ⁻¹)	bi(reg. coeff.)	S ² _{di} (mean Sq. dev.)
JI -09-21(GI 4)	0.82	0.94	0.00
GI-3 (Ch)	0.42	0.80	0.00
Mean	0.39	-	

Table 3. Comparative yield and quality attributes of JI -09-21 (GI 4)

Character	Mean	
	JI -09-21 (GI 4)	GI 3
Days to flowering	63	64
Days to maturity	102	104
Plant height (cm)	31.0	31.3
No. of tillers plant ⁻¹	6.0	5.0
No. of spikes plant ⁻¹	22.7	20.2
Spike length (cm)	4.7	4.5
No. of seeds spike ⁻¹	80.7	76.4
1000 grain weight (g)	1.579	1.542
Swelling factor (cc g ⁻¹)	11.4	9.1

Table 4. Effect of water dipping on shattering of isabgol seed

Variety	Without Dipping		H.I%	Dipping in Water (Average of four sample)			
	Dry wt. (kg)	Seed wt. (kg)		Dry wt. (initial) (kg)	Sun dry wt. (kg)	Seed wt. after threshing (kg)	Shattering of seeds (%)
GI 4 (JI-09-21)	1.027	0.175	17.03	0.894	0.731	0.115	7.25
GI 3	0.959	0.158	16.47	1.038	0.811	0.037	70.07

GI-4 recorded 89.67% less shattering than that of check variety, which revealed that Gujarat Isabgol 4 was non shattering in habit as compared to Gujarat Isabgol 3 which is prone to high seed shattering. The post dipped seed weight of GI 4, -was 0.115 kg threshed seeds, which was 96% higher than that of the post dipped seed yield of GI-3 (0.037 kg threshed seeds) (Table 4). Hence, Gujarat Isabgol 4 recommended for cultivation.

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References

Anonymous 2016a District wise area and production of spices crops in Gujarat State.

Directorate of Agriculture, Gujarat State, Gandhinagar.

Anonymous 2016b Spices exports go up by 15 per cent in value. Spices India. A Journal Published by Spices Board, Cochin. 1: 7.

Chandra V 1967 Studies in cultivation of *Plantago ovata* Forsk. Indian J. Pharm. 29: 331-332.

Prajapati D B, Patel K P & Ravindrababu Y 2011 Gujarat Isabgol-3 a promising cultivar of Isabgol. Int. J. Forest Crop Improv. 2: 81-84.

Eberhart S A & Russell W A 1966 Stability parameters for comparing varieties. Crop Sci. 6: 36-40.

Singh R N, Patel K V & Desai N N 2005 Value addition through processing of Isabgol. In: Tikka S B S, Arha M D, Jaimini S N, Tajane K R & Patel N B (Eds.). Abstr. National Symposium on Stress Management. 11-13 April, S. D. Agriculture University, S. K. Nagar, Gujarat (pp.147), Gujarat Society of Genetics & Plant Breeding, S. K. Nagar.