

Review Article

<https://doi.org/10.20546/ijcmas.2017.606.276>**Irrigation Management for Higher Productivity in Seed Spices-A Review**

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Seed spices are important commercial crops of arid and semiarid regions of India and accounting major contribution for domestic and export market. In these regions water is one of the main constraint in crop production since the growing areas are deficit in annual rainfall and these crops are grown during winter season requires assured irrigation for successful production. Among many irrigation methods including surface irrigation, drip irrigation and sprinkler irrigation are being followed widely among growing areas depends on availability of water and micro irrigation facility. But considering the importance of water for future generation and also present need, it is most necessary to workout optimum irrigation level, critical stage of water requirement and method of irrigation in seed spices to save water and to achieve higher productivity. Many research works are carried out on irrigation scheduling and water requirements of the seed spices on the basis of meteorological parameters, evapo-transpiration, soil moisture content, soil and leaf water potential. The review of the literature revealed promising results on irrigation management in seed spices. Research works on irrigation management in seed spice have been documented to understand the scope, drawbacks and feasibility to increase the productivity and to economize the water use. Many of such recommendations and present status of irrigation techniques and schedules for seed spices are presented in this article.

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10 June 2017**Introduction**

Water is prerequisite for all living beings including crops in agriculture. Water availability for agriculture is under challenge in the world as well as in India. Today, it is more important to use water resources wisely and to irrigate intelligently (Jeelani *et al.*, 2017). Assured irrigation is one of the necessary operations in agriculture particularly arid and semi-arid conditions where rainfall is scanty or limited to shorter period. In high rainfall areas like north east states, Western Ghats, coastal areas where high rainfall and water table makes the crops to survive without assured irrigation. But in

areas of arid and semi-arid region where most of the crops are annuals and cultivated by depending on rainfall and irrigation sources like tube wells, canals etc. Among them seed spices are important commercial crops grown in arid and semi-arid regions of India. In these semi-arid areas bringing new irrigation projects and converting most of cultivated area under micro irrigation is very necessary and this can save the water and increase water use efficiency of crops (Singh *et al.*, 2015). In Rajasthan state 75 per cent of the area is under rainfed condition and 35 percent of cropped area is under irrigation facility. Of

this irrigated area, 70 percent of land is irrigated by tube well and open wells and remaining 30 percent is irrigating by canals. Approximately 1.6 m.ha land is covered under micro irrigation system in Rajasthan state and 0.8 m.ha area in Gujarat as on year 2015. This indicates the potentiality of seed spices to cultivate using this micro irrigation facility and research work carried out in seed spices also implies the scope of micro irrigation in seed spices.

Seed spices are important commercial crops grown for its seed or fruit which is used as spice and condiment in various utilities such as food, bakery, confectionaries, mouth fresheners, pharmaceuticals, etc. Seed spices are collections of a wide variety of volatile and non-volatile staple dietary additives. These spices have been known for ages as effective therapeutic food. The power of seed spices to impart biological activity is now slowly re-emerging as an area of interest for human health (Rathore *et al.*, 2013). The use of spices is increasing worldwide because they are completely natural, rather than artificial additives for seasoning and flavouring foods. Seed spices are consumed as raw spice in food preparation, ground spice, mixed as *garam masala*, essential oil and oleoresins. But in India use of raw spice is more as compared any other type. Quality in terms of appearance, aroma and flavour components of spices in most important to attract the consumer preference. All the seed spices are belong to Apiaceae except nigella and fenugreek which belongs to Ranunculaceae and Leguminosae, respectively.

Status of seed spices in India

India being the world leader in seed spice production, consumption and export has to go a long way in the overall development of these crops and their growers. Important seed

spices grown in India are cumin, coriander, fennel, fenugreek, nigella, ajwain, dill, anise, celery and caraway. Among these crops cumin, fennel, coriander and fenugreek occupies major area and production. Seed spices are Rabi crops grown in all most all states of the country. Despite of having scattered cultivable area across the country Rajasthan and Gujarat are the dominant seed spices growing states. Total estimated area of seed spices in India is 14.8 lakh hectares with production of 11.6 lakh tonnes during year 2014-15. In coriander area and production Rajasthan is leading state and it is having area of 1.8 lakh hectare and producing 1.1 lakh tonnes per annum. Productivity of seed spices is very less and it is 950 kg ha⁻¹ in coriander, 530 kg ha⁻¹ in cumin, 1075 kg ha⁻¹ in fenugreek and 1680 kg ha⁻¹ in fennel. There is huge gap to achieve the productivity along with quality spices. We are leader in export of cumin and coriander in the world. During 2014-15 export of cumin and coriander reached 1838.2 and 498 crores respectively.

Irrigation methods and their importance in seed spices

Major emphasis is being given to improve the irrigation techniques and practices to increase the production and sustainable productivity of crops. Research studies carried out in different countries including India confirmed that irrigation plays a paramount role in increasing the yield and enhancing cropping intensity (Vaidyanathan *et al.*, 1994). In Agriculture various methods are available to estimate the irrigation requirements in crops. One of them is using potential evapo-transpiration based on open pan evaporation (Halepyati *et al.*, 1996). Recent trend of scheduling irrigation to crops on the basis of climatological approach has been considered as most effective and scientific, since it consider all the weather parameters in a given climate-plant environment (Parihar *et*

al., 1976). Productivity of seed spice crops are less due many factors including good seed, management practices, lack of timely irrigation, pest disease etc. irrigation methods such as surface irrigation methods like flood irrigation, check basin, furrow and ring basin are being followed from long back in which only one half of the water released is utilized for crop production (Lal, *et al.*, 2013). Excessive irrigation along with nutrition leads to vegetative growth and reduces the reproductive phase (Sharma *et al.*, 2016). Increase in the biomass leads to use of more water for biomass production leads reduction in harvest index. Water stress in plants may lead to physiological disorders, such as a reduction in photosynthesis and transpiration. It has been reported that water deficit is a primary factor in increasing oil percentage of medicinal plants and increasing irrigation times significantly decreased the cumin oil percentage. It is reported that water stress affects the crop growth and development, but influence positively on biosynthesis of secondary metabolites and enzyme activities in many medicinal plants (Ahmadian *et al.*, 2011; Laribi *et al.*, 2009; Rebey *et al.*, 2012). Based on this irrigation methods prevailing in seed spices are surface irrigation, sub surface irrigation and micro irrigation. Among these methods surface irrigation by mean of flooding is mostly practiced by farmers.

Surface irrigation methods like flood irrigation, check basin, furrow and ridges, ring basin are being followed from long back in which only half of the water released is utilized for crop production. A significant part of the applied water is lost in application, runoff and evaporation resulting in very low water use efficiency. The conventional systems of irrigation revolving round the concept of replenishing of the moisture level to field capacity after 50 to 60 percent depletion. The system do not permit the restricting of the water to meet the

requirement at the root zone, thus leading of the excessive percolation and other losses, which results in problem of water logging, soil salinity and even drought like conditions at tail ends of the system (Lal *et al.*, 2013). Flood method has been used in India for generations without any control what so ever and is called uncontrolled flooding. The water is made to enter the fields either from canals or tube well directly through irrigation channels. In this method water is allowed to flow on the surface of soil to attain the field capacity. Another method of surface irrigation practiced by farmers is check basin method. In this method after sowing of seeds of spices either by broadcasting or seed drill, small and convenient sized plots is being made by tractor drawn bund maker. Water is allowed to each plot through irrigation channels. In check basin method water used is less as compared to flooding in the whole field. Ridges and furrow method of irrigation is practiced very rarely as the seed spices are close spaced crops and lot of area is wasted if ridges and furrow method is practiced. Furrow irrigated raised beds wherein irrigation water will reach the root zone by lateral movement and does not allow creating anaerobic condition which may help for better growth and yield of cumin (Singh *et al.*, 2015).

Sub-surface irrigation, as name suggested the application of irrigation water to fields directly to the root zone of the plants. The main advantages of these type of irrigation is reduction of evaporation losses and less hindrance to cultivation works which takes place on the soil surface. Among sub surface irrigation drip and sprinkler irrigation plays significant role and occupies major areas of micro irrigation.

In drip method of irrigation water is applied to root zone of soil drop by drop so that only required amount of water is applied to the crop based on evapo-transpiration or soil

moisture status. Drip fertigation method offers nutrients application directly into the zone of crop and consequently fertilizer-use efficiency can be improved over conventional method of fertilizer application (Hebbar *et al.*, 2004). Reduction in water consumption due to drip method of irrigation over the surface method of irrigation varies from 30 to 70 percent for different crops (Lal *et al.*, 2013). In arid western Rajasthan, drip irrigation on the basis of climatologically approach hold great promise for minimizing water loss and improving its efficiency and ultimately productivity (Bhunja *et al.*, 2015). It is also suitable for wider spaced crops like fennel, ajwain, dill, celery and even narrow spaced crops such as coriander, fenugreek. Only thing is lateral spacing and spacing of drippers is to be considered while laying out the drip system in seed spices.

In case of sprinkler irrigation system either micro sprinklers or macro sprinklers water is applied in the form of rain. Even though evaporation and drifting loss of water is more in this method required volume of water may be applied (Hassan and Ali, 2016).

Sprinkler system provides the imitation of raining so that crops perform better with improved micro climate. But possibilities of disease incidence are more due increased relative humidity in the crop zone. In many crops like cumin, coriander, fenugreek, nigella where crop height is less can be equipped with sprinkler irrigation system and in long statured crops like fennel, dill and celery height of raiser is to be increased.

Problems with existing irrigation systems in seed spices

Presently surface irrigation system is widely following in seed spices cultivation. In this method farmers follow flood irrigation by allowing the irrigation water to flow in the

field as it required. This leads to loss of huge water by percolation and runoff.

Soil salinity due to excessive and unnecessary irrigation by flood irrigation in clay soils has become major problem (Godara *et al.*, 2013).

In small statured and closely spaced crops such as nigella, anise and cumin adopting drip irrigation method is difficult and needs special attention in installation of drip irrigation facility.

Cumin is highly sensitive to water stagnation. But sprinkler irrigation system will creates the humid condition the field which is favourable for incidence of *Alternaria* blight disease (Arvind *et al.*, 2016).

In the same way light irrigation under surface irrigation method (check basin method) create anaerobic conditions for few hours after irrigation may severely affect the fully developed plants by blight incidence (Singh *et al.*, 2015).

Since many of the seed spices are sown by broadcasting or by seed drills lead improper spacing for laying out drip irrigation system.

Lack of awareness among the farmers regarding technique to use drip irrigation system in seed spices, volume of water to be applied, stage of irrigation, frequency of irrigation and ideal fertigation technique.

Effect of irrigation on seed spices

Many researchers worked on irrigation management in seed spices and it has found many useful results to improve growth, biological yield, seed yield, water use efficiency and quality of produce.

In seed spices optimum irrigation is necessary to obtain high yield and good quality produce.

The review of all the work carried out in seed spices are summarized here under.

Cumin (*Cuminum cyminum*)

Cumin is a major seed spice crop with a short growing cycle, which demands little moisture and nutrient inputs. Generally cumin crop matures in about 110 – 120 days. It is being cultivated in arid regions of Gujarat and Rajasthan where soils are sandy in nature and remarked with very less rainfall. As a rabi crop cumin needs assured irrigation to germinate and maturity of crop. It is a less biomass yielding crop of arid regions. It is known that cumin is one of the drought tolerant crop in low rainfall areas, which has high water use efficiency and produces satisfactory yields with low amount of water consumption (Samadzadeh *et al.*, 2016). Cumin is highly sensitive to water stagnation. Light irrigation under surface irrigation method creates anaerobic conditions for few hours may severely affect the fully developed plants (Singh *et al.*, 2015).

Irrigating cumin crop either with drip irrigation or micro sprinkler irrigation gave better seed yield as compared to surface irrigation (Singh *et al.*, 2015). They found that water productivity was improved by drip irrigation method (41.28 kg/ha cm) followed by micro sprinkler (21.73 kg seed/ha cm) against surface irrigation method (8.43 kg seed /ha cm). Bondok and Amal, (2014) reported that saving in irrigation water by using sprinkler irrigation system was 46 % in comparing with surface irrigation in cumin crop. Seed yield of cumin increased by 10-12 percent under sprinkler system irrigation comparing with surface irrigation. Water use efficiency of cumin crop under surface irrigation decreased by 52 percent comparing with sprinkler irrigation. Use of micro sprinklers is not advocated in cumin due to requirement of more energy than drip system,

incidence of pest and disease in sprinkler (Arvind *et al.*, 2016). It also reported that drip irrigation with 0.8 IW/Etc resulted higher seed yield, plant height and dry matter of 1344.17 kg ha⁻¹, 36.42 cm and 2365 kg/ha respectively at 0.8 IW/Etc and also highest water use efficiency (5.58 kg/ha.mm) was observed at 0.6 IW/Etc. 53.3 percent of water can be saved if cumin crop is irrigated at 0.8 IW/Etc as compared to surface irrigation method. Mehta *et al.*, (2014) reported that the optimum moisture status in the root zone of the cumin crop through irrigation at 18 days interval favoured higher yield attributes which increased seed, straw and biological yield of cumin over 12 and 15 days intervals. The cumin seed yield decreased significantly with decreasing irrigation from 0.8 IW/CPE to 0.4 IW/CPE by micro sprinkler method. The highest cumin seed yield of 609 and 746 kg/ha was obtained at 0.8 IW/CPE which is significantly higher over 0.4 IW/CPE treatments that recorded only 330 and 514 kg/ha seed yield during two consecutive years, respectively. However, further increase in irrigation level to 1.0 IW/CPE was not proved beneficial for cumin.

It is also proved that highest irrigation water productivity was recorded at 0.8 IW/CPE treatments, *i.e.*, 0.281 and 0.340 kg m⁻³ of water during two years and it reduced with increase in irrigation level (Rao *et al.*, 2010). Cumin is tolerant to saline water irrigation and it is reported that maximum salinity tolerance for economical cumin yield is 5.0 dS.m⁻¹ and the most sensitive stage of growth to salt water stress in the vegetative and reproductive stages are establishment and the flowering stage (Hassanzadehdelouei *et al.*, 2013).

Essential oil content of cumin seed was observed decreasing trend with increasing irrigation levels. Increased irrigation frequencies in cumin at three times from

sowing, flowering and seed-filling stages enhanced the plant growth, seed and essential oil yields (Samadzadeh *et al.*, 2016).

Coriander (*Coriandrum sativum* L.)

Coriander is second most important seed spice crop grown for its seed as well as herb. It needs adequate moisture for its growth and development. It is possible to limit the number of irrigation up to pre-flowering stage but it is necessary to provide optimum irrigation to coriander crop at the time of flowering and seed setting stage (Verma *et al.*, 2015) and it is reported that drip irrigation at 80 percent and along with foliar spray of 25 percent nitrogen is beneficial for coriander to achieve higher seed yield. Irrigation at higher levels resulted in the highest vegetative growth and yield components in coriander compared to the lower levels (Osman and El-Feky, 2005). Flower initiation and seed development are the two critical stages of coriander for water requirement (Singh *et al.*, 2002) and Moniruzzaman *et al.*, (2013) reported that three irrigations at branching (30 DAS), flowering (60 DAS) and seed-filling stage (90 DAS) was ideal for higher coriander productivity and water use efficiency in coriander. Verma *et al.*, (2015) and Lakpale *et al.*, (2007) also reported that deficit drip irrigation at vegetative stage (60% ETC) followed by optimum irrigation in reproductive and seed development stages (80% ETC) improved the yield attributes and seed yield in coriander. This helped in increase in root growth during initial stages and later it utilizes water effectively. Tripathi *et al.*, (2009) reported that, the seed yield of coriander was significantly improved by three irrigations at 20, 40 and 60 DAS by increasing the seed yield (1.96 tonne/ha) and resulted 38.31 percent and 3.93 percent in seed yield at two irrigations (at 20 and 40 DAS) and four irrigations (20, 40, 60 and 80 DAS) respectively. Eight irrigations at 15

days interval recorded higher seed yield in coriander (Sharangi and Roychowdhury, 2014; Hassan, *et al.*, 2012). Increasing irrigation level upto 120 percent of ET will increase the seed yield and oil percentage in coriander seeds but water use efficiency decreases as increase in irrigation levels (Hassan and Ali, 2014).

It is reported that essential oil yields per plant increased significantly with increasing water regimes from 50 percent to 100 percent of the crop water need but linalool content of oil was reduced when increasing irrigation level

Fennel (*Foeniculum vulgare* Mill.)

Fennel is one of the highest biomass yielding crop among seed spices (Sonu *et al.*, 2016). It is sown as direct seeded as well as transplanted (Mehta *et al.*, 1990). Transplanted fennel can reduce the water use for initial 45 days of nursery period as compared to direct seed sown crop in the field. Productivity of fennel is low because of improper irrigation and nutrient supply. Bhunia *et al.*, (2005) reported that irrigation and fertigation improved the productivity of fennel and they found that irrigation treatment of IW: CPE ratio of 0.8 significantly out yielded the IW: CPE ratio of 0.4 and 0.6 irrigation levels. Higher irrigation frequency increased the availability of nutrients and thus enhanced the uptake of nutrients fennel. In another study Meena *et al.*, (2014) reported that fennel crop needs six surface irrigations at 20 days interval for higher productivity with use of straw as mulch. This will increase the seed yield of fennel by 37 percent as compared to four surface irrigations. Use of modern irrigation techniques to increase the efficiency of water use is important. In this regard irrigating fennel crop at 0.55 CPE volume by drip irrigation gave fennel seed yield of 14.72 qt ha⁻¹ as compared to surface irrigation (8.62 q/ha). Due to improved water

use efficiency leads to higher seed yield and drip irrigation saved 45 percent of water as compared to surface method (Yadav and Bhati, 2013). Jat *et al.*, (2015); Amin (2004) reported that, seed and biological yield of fennel can be improved by drip irrigation level at 0.8 IW/CPE ratio as compared to surface irrigation at 1.0 IW/CPE ratio. Fennel crop can produce 3.22 kg seed per hectare mm of water and irrigating crop at 1.0 potential evaporation is ideal (Meena *et al.*, 2016). Similarly Patel *et al.*, (2007) stated that, irrigation at 0.9 IW:CPE ratio is optimum for higher productivity. The response of fennel to irrigation in yield improvement was found to be different in different agro-climatic and soil conditions in India. In order to improve the water use when non availability of modern irrigation techniques, the use of suitable traditional methods is important. Among them trench method of irrigation is found best for fennel crop as compared to check basin and border strip method (Bhardwaj and Agrawal, 2014). In trench irrigation, lateral movement of water in to the root zone of fennel crop leads to less evaporation and less compaction which benefited in obtaining higher seed yield. Soleymani and Shahrajabian (2012) observed that irrigating fennel crop at flowering stage is the most important for improving seed yield. In most of the studies 0.8 IW/CPE ratio yielded better in fennel.

Fenugreek (*Trigonella foenum-graecum*)

Fenugreek is a multipurpose crop grown for herb as well as seed. In north Indian conditions fenugreek is grown as winter crop with limited water and use of less or no fertilizers (Sharma *et al.*, 2016). Being a legume crop among seed spices it needs less nitrogen by fixing symbiotically in root nodules but it performs positively to applied water as irrigation. Fenugreek is highly sensitive to water stress during the flowering

and pod filling stages but excess irrigation may lead to heavy vegetative growth and shortening of reproductive period and ultimately decrease the yield (Sharma *et al.*, 2016). Hence ideal irrigation level and time of irrigation is very much critical in fenugreek cultivation. Lal *et al.*, (2013) reported that various methods of irrigation influenced the seed yield of fenugreek, among them drip irrigation method and sprinkler irrigation method recorded at par results. It because in these methods water was applied at frequent interval at right time and quantity as compared to surface irrigation. Drip system recorded 29.5 percent higher seed yield as compared to surface irrigation. Dhaker *et al.*, (2016) reported that higher seed and haulm yield under IW: CPE ratio 1.0 is ideal for fenugreek and they find that it is favourable soil moisture during major part of crop period including critical stages (flowering and pod formation) of fenugreek crop. Sharma *et al.*, (2016) observed that surface irrigation of fenugreek crop at two rates *i.e.*, 0.6 IW:CPE at vegetative stage + 1.0 IW:CPE at reproductive stage recorded 16.5 percent higher seed yield as compared to surface irrigation at 0.6 IW: CPE + 0.8 IW: CPE ratio. In another study conducted by Lakpale *et al.*, (2008) and Bhunia *et al.*, (2015) reported that three irrigations are mandatory for fenugreek at 35, 60, 80 days after sowing and they also reported that increased number of irrigations at 0.6 CPE or 0.8 CPE is also beneficial for achieving higher seed yield.

Nigella (*Nigella sativa*)

Nigella is one of the important seed spice as well as medicinal plant cultivated for its seeds. Nigella crop takes 170-180 days to mature. Nigella crop is able to tolerate moisture stress and it can tolerate water stress except at seed formation stage (Bannayan *et al.*, 2008). They also reported that, seed yield of nigella was reduced when irrigation was

stopped at blooming stage which reduces the number of seeds per plant but no differences in oil content were observed by deficit irrigation. If irrigation frequency increased to six days interval by drip irrigation method at time of pre flowering and post flowering stage leads to reduction in plant growth and seed yield (El-Mekawy, 2012). It means that, ideal soil moisture is most necessary at the time of flowering seed setting stage in nigella. Using drip irrigation method in nigella, water use efficiency can be improved when irrigation is given at 50 percent of evapo-transpiration (ET) rate. Water use efficiency of nigella at 50 percent ET is 1.39 kg seed ha⁻¹ mm of water (Ghamarnia *et al.*, 2010). It is also reported that, excess irrigation causes root rot problem and low irrigation caused attack of termites in sandy soils. This is needed to be taken care to reduce the cause of these two problems in nigella cultivation.

If irrigation water is terminated at flower bud formation stage seed yield will be reduced and it is observed that, moisture stress at this stage (bud formation) increases the essential oil, carvone and thymoquinone content of seeds (Hadi *et al.*, 2016). Hence it is utmost need to irrigate the nigella crop at flowering and seed formation stage for higher productivity.

Caraway (*Carum carvi* L.)

Caraway is minor seed spices grown in Himalayan tracts of India and other Mediterranean region. It is spice and also a medicinal plant used as antioxidant, antibacterial and other. The main essential oil constituents were carvone and limonene which showed an increasing of their contents under water deficit levels.

Thus, water deficit induced a significant reduction in growth parameters and fatty acid content, and an increase in the essential oil compounds at medium water stress (Laribi *et*

al., 2009). Total fatty acids content of caraway seeds decreases significantly by about 35.17 and 56.59 percent under medium water deficit and severe water deficit, respectively, in comparison to the seeds of no moisture deficit.

Celery (*Apium graveolens*)

Celery is seed spice cum condiment crop used for seed and as well as leaf petiole in flavouring of food items. In India it is cultivated for seed purpose. But celery is one of the high biomass yielding crop mainly leaf and main stem which bigger in size. It is extremely sensitive to water stress leads to pithiness of petioles, which is common problem in drip-irrigated fields or low irrigated crop or short-term water stress.

It is reported that to obtain higher growth rate and quality of celery requires high soil moisture content that is not more than 20-30 percent of available water in the primary root zone to be depleted between irrigations (Hartz, 2000). Since celery is one of the higher biomass yielding crop requires more water to produce biomass.

Opportunities to improve the water use efficiency in seed spices

There are several opportunities for improving the water productivity of seed spices in India.

They are providing full irrigation to meet the full crop evapo-transpiration demand or providing supplemental irrigation in critical periods of crop growth for the rain-fed crops for increasing the crop yield

Replacing old and less effective means of irrigation with more efficient and durable methods such as drip irrigation and sprinkler irrigation system where ever necessary to increase the water use efficiency.

As a part of good agriculture practice use of drip irrigation technique will offer safe delivering of water, pesticides, nutrients in required quantity and requires time.

Adopting transplanting techniques in seed spices such as fennel, dill, Ajwain, celery and Anise crop leads to water saving by nursery period and advancement of crop by maturity. Use of mulch materials like plastic mulching sheet, crop waste as anti-evaporates to save the irrigated water from the soil surface so that irrigation frequency can be reduced thereby saving water, energy and cost of production (Meena *et al.*, 2014., Yadav and Bhati, 2013).

Breeding of water efficient varieties such as short duration varieties which require little irrigation as compared to long duration ones, varieties which are tolerant to moisture stress, high yielding varieties without increasing the crop consumptive use are need to be prioritize in seed spices.

Improving the water holding capacity by adding more organic matter to soil so that applied water by any means may be preserved in the soil.

Combining irrigation water, fertilizer and pesticide application to increase the efficiency of irrigation system and also input use efficiency in long duration and high nutrient demanding seed spices such as fennel, Ajwain, Nigella and celery.

Exploring the possibility of cultivation of tolerant seed spices such as cumin, dill, fennel and celery in saline and alkaline soils. Since these crops are fairly tolerant to salinity and alkalinity (Annonymus. 2015). In these conditions use of drip irrigation can yield better without increase in the salinity/alkalinity level of the soil.

Based on all the research work carried on irrigation management in seed spices to improve productivity, it is found that still more work is required to understand the crop water requirement particularly critical stages of water requirement, use of sensors in irrigation quantification. It is proved that increased irrigation level will increase the biomass content but reduces the water use efficiency in producing economic yield. This is the area where research is required to improve use efficiency of inputs such as moisture, nutrients, energy etc by various moisture retention techniques to increase the economic yield rather biological yield or it can also say that higher harvest index. Hence each and every drop of applied water is to be utilized by the crop so that higher water use efficiency can be achieved. In seed spices quality is most important along with optimum productivity hence focus on improving quality with seed yield is most necessary. In most of the studies either by drip irrigation or surface irrigation methods irrigating seed spices at 0.5-1.0 IW: CPE ratio is found optimum. But, instead of irrigating crops by visual assessment without quantifying the water leads to huge loss. It is also found that flowering and seed setting stage is most critical in coriander, fennel and nigella for its quality improvement. Hence irrigating the crop according to soil moisture status, crop need and climatic condition by following suitable moisture conservation techniques is most important in seed spices.

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