An Experimental study on Super Absorbent Polymers and application of Deep Pipe irrigation technique for water efficient irrigation in semi-arid drought prone regions for horticultural crop under small scale farming

Rajiv Bharatbhai Dabhi[1]
[1]*Senior Lecturer, Civil Engineering Dept., Govt. Polytechnic, Jamnagar, Gujarat, India*

Abstract: *The effect of Super Absorbent Polymers (SAP) in soil amendments with conventional irrigation and effect of Deep pipe irrigation technique with and without SAP amended soil were evaluated after studying morphological parameters like Leaf growth, Plant height, Stem developments, Root growth and yield of the Cherry Tomato plant in a potted cultivated field experiment conducted under semi-arid, drought prone region for small scale horticultural farming by the application of reservoir storage water in different watering intensities (80%, 65% and 50%). The results show that application of SAP could increase soil moisture content and impart significant effect on the yield by sustaining for nutrient and other necessary elements. More development of leaves could increase evapotranspiration and metabolism in the plants while more root growth given out more stability and nutrient intake to the plant which subsequently increased plant height, stem development. Deep pipe (DP) is furthermore helpful in reducing water application to the plant compared to the growth and yield parameter of the plant but not gave compatible results with SAP though it is also suggested to get more efficient water management in the drought prone water scares areas as compared to conventional irrigation (CI) methods of irrigation. Soil amendments with SAP and irrigation with deep pipe (DP) method performed well but simultaneous cost of SAP in addition to deep pipe and more irrigation in the lower bottom part of the root zone found less advantageous.*

Key words: Super Absorbent Polymers, Deep Pipe Irrigation, Plant Morphology, Yield

Introduction

Semi-arid regions of Asia (especially India), Middle-East and Sub-Saharan Africa are profoundly populated and majority living below poverty line. Among them by 2025 the problem of water scarcity in India will be severest (Saleth, 1996) which is also concluded by the central water commission (CWC), Govt. of India, (1996, 1998, 2002, 2004). As agriculture is the major consumer of water (T.B.S. Rajput and Neelam Patel, 2012) has anecdotal that micro irrigation methods need to be employed for efficient distribution and application of water for crop production. But high initial cost, inadequate funding, lack of availability of technical input and after sale services, clogging of dripper and cracking of laterals, damages due to rats and squirrels, high cost of spares and components, discrimination in subsidy distribution among different categories of farmers etc. are some of the major constraints faced by Indian farmers in the opinion of Dr. K. T. Chandy. Moreover, S. Mahendra Dev, (2012) has distinguished that in India around 98 million out of total 120 million farm holdings are small and marginal farmers; the sustainability of these farmers is crucial for livelihoods in rural areas and for the entire country and the net farm income is also low for small holding. Therefore, the stress on agricultural development in the

present has shifted to the sustainable use of land, water and plant resources in agriculture. The major goal of the present day agriculture is to maximize land and water productivity without threatening the environment and the available natural resources.

SAPs are hygroscopic and biodegradable (Fidelia N. Nnadi, 2012) materials can be used for agriculture as it can absorb and store up to 400 times their own weight of water (Fonteno W. C. and Bilderback, 1993). Francesco Puoci et al.(2008) have found that in agricultural field this smart delivery system used to improve irrigation efficiency which was also inveterate by Hossein Nazarli et al. (2010) Alessandro Sannino, (2008) and S. Shooshtarian et al. (2011); to combat viruses and crop pathogens, to increase the efficiency of pesticides and herbicides which is also considered to be one of the major constraints in designing efficient irrigation technology as per M. Robiul Islam et al.(2011), allowing lower doses to be used and to indirectly protect the environment through filters or catalysts to reduce pollution and to clean-up existing pollutants. Moreover Morante, J., (2009) widen the scope of SAP to use rainwater and deliver to plants until the next storm.

To supplement water efficiency in irrigation, a technique of Deep pipe irrigation was also studied during this experimental research work. This technique was initiated by the Bainbridge (1991) and Mac Aller (1996) they had a wide experiments in the deserts. Method uses an open vertical or near vertical pipe to concentrate irrigation water directly in to the deep root zone the phenomenon was previous suited by the Mathew (1987) and Bainbridge (1990) in Virginia. Concept of Deep root irrigation is also done by Sawaf (1980) his experiments in Africa demonstrated that the deep pipe drip system is much more efficient than surface drip or conventional surface irrigation. It is possible to set up with simple materials and unskilled labor. Experimental fruit crop production became almost doubled by using this method in irrigation David A. Bainbridge (2002). Deep pipe irrigation is normally done with 1-3 cm diameter pipe (Low cost PVC material, Bamboos etc.) placed vertically in the soil 30-50 cm deep near the seedling or tree with a screen cover (1 mm hardware cloth) to keep out borrowings animals and insects. The top of the pipe may be set close to the ground to minimize visual contact, or may lengthen above ground by around 20-40 cm. A string of 1-2 mm holes should be spaced about 5-7.5 cm apart down the side of the pipe nearest the plant to facilitate root growth in the early stages of development and much essential for the root growth of shallow rooted plants (San Diego State University).

Keeping in view the above mentioned characteristics of SAP and deep pipe irrigation technique different combination of techniques were made and studied the irrigation efficiency and response of the various morphological characteristics of the plants and yield.

MATERIALS AND METHODS

The experiment was conducted in the field located at semi arid, coastal and water scare western most region of India (N22.28° E70 3º, Jamnagar, Gujarat state).

Agricultural SAP was brought from AQUARESERVE®, Dhruviraj Syndicate, Ahmadabad (Gujarat, India), Seedling trays, PVC pipes 2.5cm dia. and 30cm long – 2no. per container, Cherry tomato seeds brought from Namdhari seeds , There were 4 combinations (CI - conventional irrigation; SAP – soil amendment with 4% w/w (Rajiv Dabhi et. al.2013) of soil for conventional irrigation; SD - soil amendment with 4% w/w of soil for deep pipe irrigation; DP – without soil amendment for Deep pipe irrigation technique) of irrigation techniques and 4 different irrigation intensities (100%, 80%, 65% and 50%), 5 replicates of CI method and 3 replicates of other mentioned treatments as total 32 plastic containers (LBH - 25cm x 25cm x 35cm) and Tap water @ 390PPM (Rajiv Dabhi et. al.2013) were collected for the field experiment. No fertilizer and pesticides were applied in the intension to find out water efficiency.

Determination of Morphological features of the Plants Nos. of leaf of each plant was physically counted from the sowing to maturity stage. Height of each plant was measured with metal tape from soil level to the extreme head of the plant up to maturity stage. Stem thickness of each plant was precisely measured with vernier scale. Weight of each plant root was measured on the digital scale. Yield physically collected and weighted on the digital weighing machine.

RESULTS AND DISCUSSION

Leaves development

Analysis of the variance showed that SAP was less effective in the initial stage and growth stage but more significant after late season stage (Fig. - 1). It is noticeable that leaf growth is more for SAP50% and reached nearly equal to SAP 80% and far more than CI. It shows SAP and soil mixture provided optimum moisture level even with 50% irrigation water. On the other hand SD80% gave better performance than CI but less than SAP50% and SD65% and SD50% not performed well hence cost of suppliment irrigation method to SAP not justified in leaf growth. While DP80% DP65% and DP50% gave less leaf growth than other combination though with DP50% leaf growth were almost 80% of CI which is sizeable. Positive effect of SAP on the leaf growth could be the result of high potential of SAP to absorb water and soil moisture retention. This was also accomplished by Patil Appa Ananda (2009).

Height development

Soil moisture content appears more significant for the growth of plant height (Fig. - 2). Other than the initial stage in all other stages plant height is more or less proportional to the irrigation water intensities. Increased moisture content level with the help of SAP increased plant height even with less water hence irrigation efficiency were increased. SD variant is also not justified in the growth of the plant height. While DP variant also showed similar results as of SAP but overall height found lesser than SAP variant. Hence it can be suggested that high moisture level with SAP amendment in soil can helps to improve the plant height. Where reduction in water supply caused a decrease in cell elongation, turgidity, cell volume and nos. of stem cells ultimately reduced the plant height (Yang et. al. 2006) Similar results have been reported by Al-Harbi et al. (1996), Sivalapan (2001) and Sendur Kumaran et al. (2001).

Stem development

Plant height and stem thickness reflects overall plant growth which is influenced by the interaction between the environmental conditions and the genetic make-up of the plant nevertheless as noticed earlier soil moisture content helps to improve cell development stem growth were also influenced by SAP in the initial and growth stages of the plant (Fig. – 3). In the later stages it was being influenced by DP irrigation method. DP irrigation helped more root development at the lower part of the container which gave more stability to the plant hence equivalent thick stem were observed. Anupama et al. (2005) also reported same findings after the performance of SAP (0.5% wt/wt) compared to control.

Root development

Root environment plays important role in the overall development of the plant, which includes water availability; salinity and root temperature. Moisture supply plays an important role in the supply and distribution of the nutrient to the plant from the soil. On the contrary water logging cause poor uptake of water and poor aeration in the root zone. Anonymous (2001) stated that soil should be well drained specially in the wet season. Observations and measurements of the root weight after harvesting clearly indicated that polymers significantly increased root length as well as root mass and weight as compared to control and DP method (Fig. – 4) which is in accordance

with the results of Taylor and Halfacre (1986). SD method has given slightly superior results in the root growth as compared to the other previously discussed parameters. That is because of the increased root growth in the bottom portion of the container due to deep pipe irrigation supported by SAP. DP method has given equivalent results as of CI even with lower watering intensities. Similar root development is found with DP50% compared to CI; hence DP has given affirmative results in compare to the CI method.

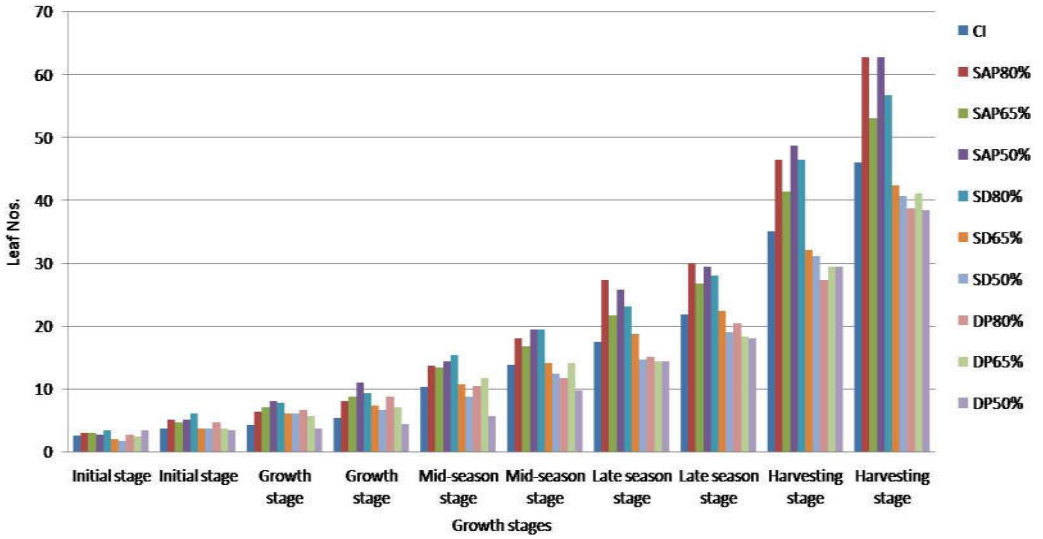

Figure.1 – Effect on leaf development during various growth stages of the plants under different irrigation methods and watering intensities.

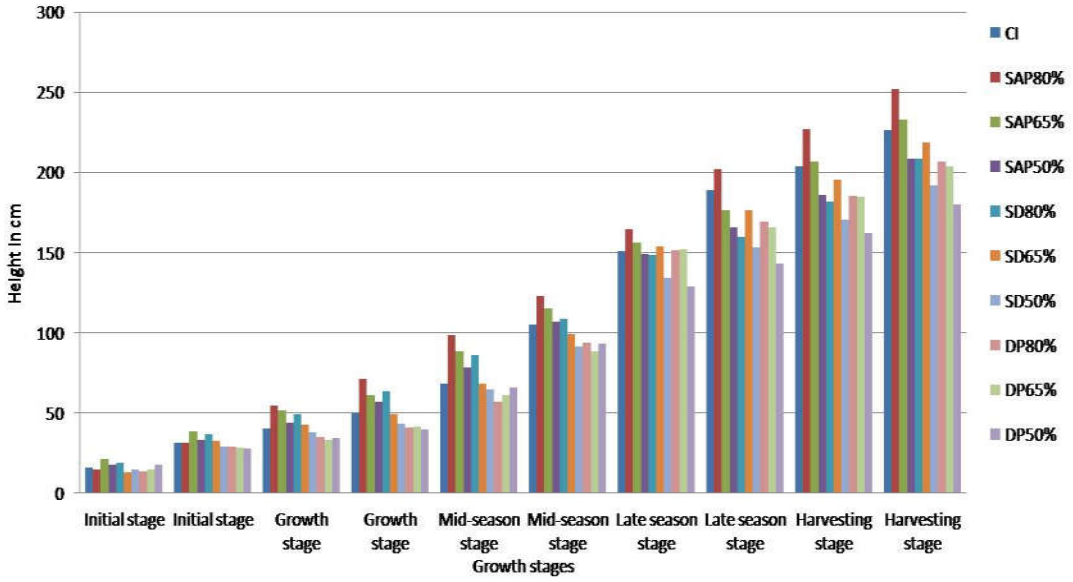

Figure.2 – Effect on height development during various growth stages of the plants under different irrigation methods and watering intensities.

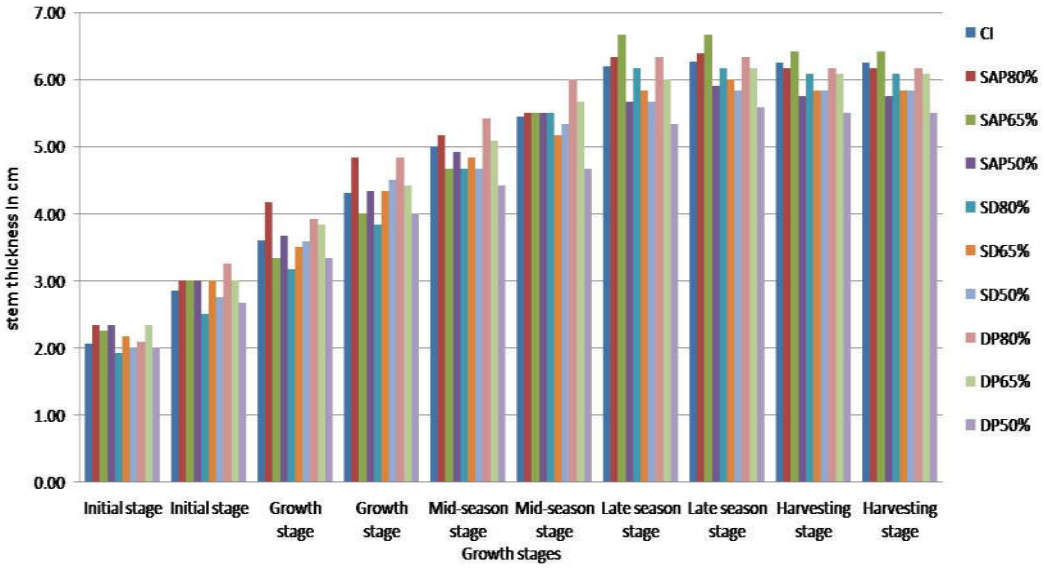

Figure.3 – Effect on stem development during various growth stages of the plants under different irrigation methods and watering intensities.

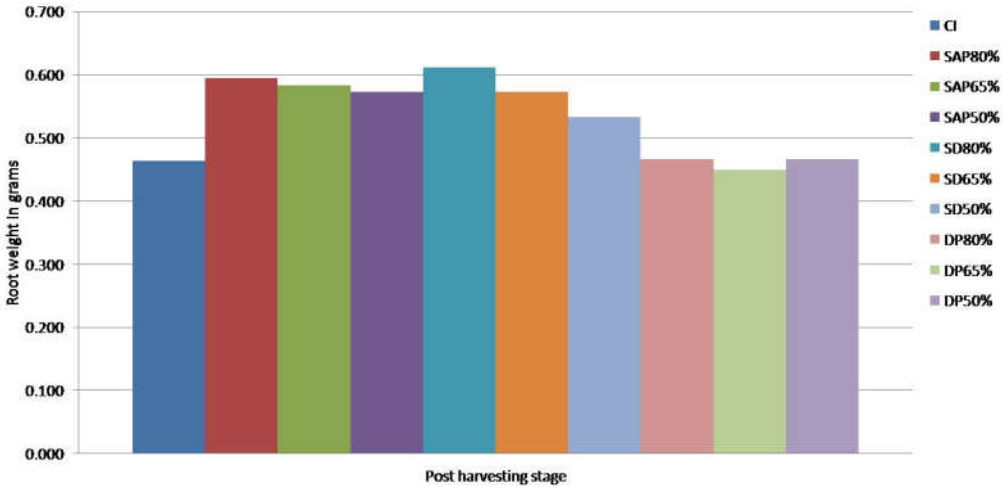

Figure.4 – Effect on root development after post harvesting stage of the plants under different irrigation methods and watering intensities.

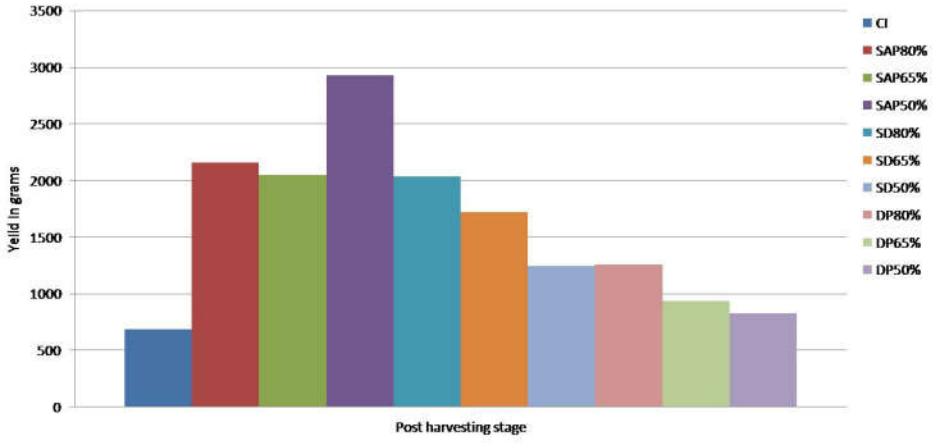

Figure.5 – Effect on the cumulative yield at post harvesting stage of the plants under different irrigation methods and watering intensities.

Yield

Remarkable results were observed (Fig. – 5) that SAP80%, SAP65% and SAP50% has given out fabulous cumulative yield after post harvesting stage compared to control in CI. In SAP also with SAP50% has given out highest yield. It shows that in water stress condition, yield level may be sustained or rather enhanced by using new advanced initiatives SAP. SD method has also given much higher yield compared to CI but do not compatible with SAP as in SD additional cost of deep pipe is not justified. Moreover more concentration of water in the deeper zone helped to grow more root but less moisture in the upper part of the root zone hampered the yield as highest nutrient absorption is from the upper middle part of the root zone. Comparable results also achieved in case of DP but lower yield due to absence of SAP. As yield is the governing parameter in the agricultural as well as horticultural crop, SAP has proven its effectiveness. Alike results were also noticed by Tripathi *et al.* (1997) as compared to control. Highest tuber yield were reported when SAP was applied with potassic fertilizers into the soil (Janardhan Singh, 1999). While Sivalapan (2001) found that Polyacrylamide (PAM) have given out multiple times grain production than that in control soil. Similarly, Sendur Kumaran *et al.* (2001) found increased number of fruits, fruit weiht and yield per plant in tomato when soil was treated with polymer, which were in accordance with Dhumal (1993) and Cookson *et al.* (2001). Hence present study indicated that SAP50% have maintained optimum moisture level in the soil with could helped in supplying the most nutrients and other required supplements for better yield.

Conclusion

According to this field experiment and subsequent evaluation of different suggested irrigation methods, based on the record of morphological parameters of the plant and water supplied to the plants during whole growth period of Cherry Tomato plants, it shows that overall leaf growth, height of the plant, stem development, root growth and ultimately yield has a beneficial impact with the application of SAP in the soil. SD method is also compatible but not justified all the parameters while DP may justify few morphological parameters by growth but gave negative results in compare to SAP. Hence amendments of SAP in soil have a highly significant effect on the growth and well as yield of the plant. This study provides important basis for the promotion of SAP amendments in the arid and semi arid drought prone regions of the western part of the India in the small scale agricultural and horticultural farming. Further research on SAP should also be considered for its application rate and effectiveness on the different soil types and its characteristics and variety of crops.

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