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Rajni Solanki
Department of Horticulture, College of Agriculture, JNKVV, Jabalpur, Madhya Pradesh, India

BP Bisen
Associate Professor, Department of Horticulture, College of Agriculture, JNKVV, Jabalpur, Madhya Pradesh, India

SK Pandey
Professor, Department of Horticulture, College of Agriculture, JNKVV, Jabalpur, Madhya Pradesh, India

Corresponding Author:
Rajni Solanki
Department of Horticulture, College of Agriculture, JNKVV, Jabalpur, Madhya Pradesh, India

Effect of super absorbent polymer and irrigation scheduling on growth attributes in acid lime

Rajni Solanki, BP Bisen and SK Pandey

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Abstract
The experiment was undertaken at Fruit Research Station, Imalia, College of Agriculture, JNKVV, Jabalpur during the year 2019-20. The response of super absorbent polymer and irrigation scheduling on growth, yield and quality attributes in acid lime was evaluated. The experiment was laid out in Randomized Block Design with three replications and total 13 treatments combinations including control. Statistically analyzed data shows that among the treatments the maximum increase in plant height (0.65 m), canopy spread E-W direction (0.55 m) and N-S direction (0.57 m), shoot length (12.45 cm), leaf length (6.43 cm), leaf width (3.44 cm) and leaf area (14.58 cm^2), fruit length (47.26 mm), fruit width (40.51 mm) and chlorophyll content (60.60 SPAD value) which was significantly superior among all the treatments and control.

Keywords: Acid lime (*Citrus aurantifolia*), Super absorbent polymer (Hydrogel), Growth attributes, Irrigation scheduling

Introduction

Citrus species are extensively cultivated in tropical and subtropical regions around the world and occupy premier position both in area and production. Acid lime (*Citrus aurantifolia* Swingle) is sub-tropical fruit crop and flowers thrice in a year that is in the month of Jan- Feb, June-July and Sep- Oct and generally known as Ambia, Mrig and Hasta bahar respectively. Acid lime is known as Kagzi lime or neembu belongs to the family Rutaceae. The word kagzi being derived from the word kagaj meaning paper, as the rind of the fruit is very thin. Acid lime fruits have great medicinal value and nutritional value being acidic. Besides it's value added products like pickle, juice, squash etc. lime peel oil, citric acid, peel powder are also in great demand in cosmetic industry.

Limes are nutritional powerhouses, loaded with Vitamin C, antioxidants and nutrients, that may help boost immunity, reduce heart risk, prevent kidney stones, checks biliousness, antihelmintic, aid iron absorption and promote healthy skin (Raman, 2019) [19]. The USDA nutrient database lists the nutritional values per 100 g of edible lime; Energy 126 kJ (30 kcal), Carbohydrates 10.5 g, Sugars 1.7 g, Dietary fiber 2.8 g, Fat 0.2 g, Protein 0.7 g, Vitamin C 29.1 mg, Calcium 33 mg, Iron 0.6 mg, Potassium 102 mg and water 88.3 g (USDA, 2019) [22].

In India production of acid lime estimated 3148.5 million tonnes from an area of 286.2 million ha with an average productivity of 11 t/ha during 2017-18. In Madhya Pradesh acid lime cultivated over 20.29 million ha with an annual production of 306.73 million tonnes and productivity of 15.11 tonnes/ha (Anonymous, 2018) [3].

Most of the fruit crops are adversely affected by the osmotic stress arising due to poor water availability and/or excess salts in the root zone. Irrigation water stress is one of the major limiting factors that affect crop, fruit growth and productivity. Plant productivity is often also limited by adverse physical and chemical soil properties such as low infiltration rates as well as low water retention and low cation exchange capacity (Pattanaaik *et al*., 2015) [18]. In addition to water deficit, ion toxicities pose an additional risk to the crops grown in salt-affected soils. Even crops considered to be fairly drought and salt tolerant (*e.g.* olive) exhibit marked declines in growth and fruit yield upon prolonged exposure to these stresses. Although several biological and agronomic options have been suggested to improve plant tolerance to these stresses, Super absorbent polymers (hydrogels) are increasingly being tested to manage water and salt stresses in a number of field and horticultural crops (Verma and

Singh, 2018) [23] are constraints that hinder their widespread commercial applications.

Hydrogels are sometimes referred to "root watering crystals" or "water retention granules" because it swell like sponges to be as several times of their original size when it contact with freely available water, consequently increase soil water holding capacity and reduce irrigation frequency (Barkat *et al*., 2015) [5]. SAP (super absorbent polymer) used in agriculture are mostly prepared from acrylic acids and a cross-linking agent like potassium by solution or suspension polymerization. The polymer so formed is called a polyacrylate whose swelling capacity and gel modulus depends greatly on the quantity and type of cross-linker used. Hydrogel also known as SAP (super absorbent polymers), stockosorb absorbent polymers, absorbent gels, super soakers, super slurpers and water gel. It is a white crystalline granule, non-toxic, non-irritating and non- corrosive in nature and tested to be biodegradable with a degradation rate of 10%-15% per year (Anonymous, 2018) [4].

According to many authors, superabsorbent polymers also have a beneficial effect on plant nutrient uptake, and increase the saturation of the sorption complex with bases, which prevents leaching losses of nutrients, thereby increasing the effectiveness of fertilization, and conduces to environmental protection. As many researchers have stated, superabsorbent polymers also bind heavy metals and decrease their availability for plants. The use of hydrogel reduces the accumulation of zinc and lead in the leaves and copper, nickel and lead in the fruit of strawberry (Mikiciuk *et al*., 2015) [15]. Hydrogel have been successfully used as soil improvers to increase the water-holding capacity and/or nutrient retention of sandy soils, with a possible reduction of irrigation frequency, compaction tendency and water run-off (Francesco *et al*., 2015) [8].

Method and Material

The experiment was carried out at Fruit Research Station, Imalia, Department of Horticulture and the chemical analysis of fruits was done in the Post Harvest Laboratory, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, (M.P.). Jabalpur is situated at "Kymore plateau" agro-climatic region of Madhya Pradesh at 23.10^0 N latitude and 79.58^0 E longitude having an altitude of 412.08 meter above the mean sea level. The soil of the experimental site was medium black clay loam with good drainage and uniform texture with of average NPK status. It is tenaciously sticky when wet and hard when dry. All the selected plants were healthy, uniform and received recommended agricultural practices. The experiment was laid out in randomized block design with three replications and 13 treatments, irrigation scheduling were 15%, 30%, 45% and 60% water depletion in combination with zero, 25g and 50g SAP along with control. Potassium based super absorbent polymer (SAP) granule was used. After the application of SAP, soil was filled back into the trench. Then irrigation was applied in the basin as per treatments. The height of the plant, canopy spread in E-W and N-S directions was measured (from ground level to the terminal shoot) with the help of measuring tape. Chlorophyll content in leaves was estimated by using instrument SPAD chlorophyll meter. The leaf length and width was recorded at the harvesting stage of the crop with the help of scale. From the tagged shoots fruit length and width was measured in centimeters with the help of digital Vernier callipers. Shoot length of newly emerged shoots after polymer application, were recorded from base of the shoot to the tip in centimeters with the help of scale. The obtained data were tabulated and subjected to analysis of variance (ANOVA) according to Fisher, 1935 [7].

Results and Discussion

As per result indicated in table 1, that both polymer and water regime significantly affected vegetative growth *viz*. plant height, canopy spread (E-W and N-S directions), shoot growth and chlorophyll content in leaves. Highest plant height (0.65 m) obtained with treatment T_6 followed by treatment T_5 and shortest (0.13 m) in control. Water stress reduces plant height and resulted in stunted growth, while polymer inhibits incidence of this phenomenon (Ghehsareh *et al*., 2010) [9]. Many studies, in general, indicated that SAP had caused an improvement in plant growth by increasing water holding capacity in soil (Kassim *et al*., 2017) [12]. These results are in agreement with Ghehsareh *et al*., 2010 [9]; Amiri *et al*., 2013 [2]; Fernando *et al*., 2013 [6]; Kassim *et al*., 2017 [12]; Singh *et al*., 2020 [20]; Khonglah *et al*., 2016 [13]; Waly *et al*., 2015 [24] and Zoghdan *et al*., 2019 [27].

Highest canopy spread 0.55 m and 0.57 m in E-W and N-S directions, respectively obtained with treatment T_6 and minimum canopy spread observed with control. Whereas, maximum leaf parameters *viz*., leaf length (6.43 cm), width (3.44 cm) and leaf area (14.58 cm^2) were recorded with the treatment T_6 followed by treatment T_5 and T_8, minimum values recorded under control. These findings may be due to the ability of plants to more efficiently photosynthesize under non water stress conditions, which in return reflected on vigorous plant growth. Also, other studies reported that soil water deficit was sufficient to close stomata which inhibit other physiological processes such as net photosynthesis and leaf elongation.

Table 1: Morphological changes in acid lime as influenced by SAP and water depletion

Treatments	Plant Height (m)	Canopy spread (m)		Shoot length (cm)	Chlorophyll content (SPAD)
		E-W	N-S		
Control	0.13	0.13	0.13	8.41	52.37
T_1: No polymer + 15% water depletion	0.17	0.23	0.30	8.60	52.93
T_2: 25g polymer + 15% water depletion	0.18	0.37	0.38	10.34	58.57
T_3: 50g polymer + 15% water depletion	0.20	0.27	0.43	10.70	58.92
T_4: No polymer + 30% water depletion	0.20	0.17	0.17	10.12	56.78
T_5: 25g polymer + 30% water depletion	0.45	0.38	0.53	10.88	59.52
T_6: 50g polymer + 30% water depletion	0.65	0.55	0.57	12.45	60.60
T_7: No polymer + 45% water depletion	0.27	0.22	0.20	10.34	54.42
T_8: 25g polymer + 45% water depletion	0.33	0.23	0.40	10.83	56.83
T_9: 50g polymer + 45% water depletion	0.37	0.45	0.47	11.75	59.27
T_{10}: No polymer + 60% water depletion	0.18	0.20	0.27	8.59	53.40
T_{11}: 25g polymer + 60% water depletion	0.23	0.20	0.30	9.67	57.07

T_{12}: 50g polymer + 60% water depletion	0.28	0.33	0.37	10.04	58.03
S.Em±	0.097	0.110	0.12	1.41	2.78
CD at 5% Level	0.28	0.32	0.37	4.13	8.13

Highest shoot length was observed with treatment T_6 (12.45 cm) followed by treatment T_5 and minimum shoot length was noticed under control. These results are consistent with the findings of Zonta *et al*., (2009) [28] who concluded that the addition of hydrogel to soil optimized the availability of water, reduced the loss by nutrient percolation and leaching and improved the soil aeration and drainage, accelerating the shoot development of plants. These results are in the line with those of Khonglah *et al*., 2016 [13] and Zoghdan *et al*., 2019 [27].

Table 2: Influence of SAP and water depletion on leaf parameters and fruit dimensions

Treatments	Leaf			Fruit dimensions	
	Length (cm)	Width (cm)	Area (cm^2)	Length (mm)	Width (mm)
Control	5.63	2.77	10.31	39.99	37.60
T_1: No polymer + 15% water depletion	5.97	3.09	11.87	43.69	38.01
T_2: 25g polymer + 15% water depletion	5.64	3.03	11.34	42.57	38.14
T_3: 50g polymer + 15% water depletion	6.02	3.23	12.56	42.71	39.14
T_4: No polymer + 30% water depletion	5.72	3.03	10.89	42.47	37.43
T_5: 25g polymer + 30% water depletion	6.24	3.35	13.51	45.46	40.29
T_6: 50g polymer + 30% water depletion	6.43	3.44	14.38	47.26	40.51
T_7: No polymer + 45% water depletion	6.04	2.93	11.82	40.76	38.69
T_8: 25g polymer + 45% water depletion	6.38	3.13	12.20	45.09	39.64
T_9: 50g polymer + 45% water depletion	6.40	3.17	12.82	44.40	38.89
T_{10}: No polymer + 60% water depletion	6.00	2.86	10.73	40.64	37.77
T_{11}: 25g polymer + 60% water depletion	5.51	3.07	11.32	41.60	38.51
T_{12}: 50g polymer + 60% water depletion	5.64	3.10	11.49	42.73	38.66
S.Em±	0.30	0.16	1.13	1.99	1.11
CD at 5% Level	0.88	0.47	3.30	5.81	3.24

There are following mechanisms for the explanations: First, the roots took water retention from polymer during water shortage; Second, the addition of natural polymer has a positive effect on CO_2 assimilation rate and the water use efficiency of plants that grown under water stress condition, thus significantly affecting plant growth and biomass accumulation (Jamnicka *et al*., 2013) [11]. Also, the plants that grown in hydrogel, produced plants with large volume comparing with those grown in media free of hydrogel (Barakat *et al*., 2015) [5]. The similar results for plant growth attributes were obtained by Fernando *et al*., 2013 [6]; Torkashvand *et al*., 2017 [21]; Oraee and Moghadam 2013 [17]; Liu *et al*., 2016 [14]; Waly *et al*., 2015 [24] and Zoghdan *et al*., 2019 [27].

As for fruit dimensions maximum fruit length and diameter were recorded under treatment T_6 47.26 mm and 40.51 mm, respectively followed by treatment T_5 and small size fruits were obtained under control. Similarly, Singh *et al*., 2020 [20]; Namvar *et al*., 2014 [16] and Yazdani *et al*., 2007 [25] also reported improvement in fruit dimensions due to the application of SAP.

The treatment T_6 had highest SPAD value (60.60) followed by treatment T_5 as compare to other treatments and minimum value was observed with control. Zhang *et al*., (2006) [26] were also found that the retardation in the content of photosynthetic pigment, because of water stress. Earlier studies mentioned that the reduction in leaves chlorophyll content of the plants grown under stress has been attributed to the destruction of pigments and instability of the pigment protein complex (Jaleel *et al*., 2008) [10]. The results obtained in this study are in conformity with the findings of Amirri *et al*., 2013 [2]; Fernando *et al*., 2013 [6]; Ahmed and Fahmy 2019 [1] and Waly *et al*., 2015 [24].

Conclusion

The results showed that using a super absorbent polymer (SAP) and Irrigation regime has positive significant effects, on attributes like plant height, canopy spread, Shoot length, chlorophyll content, Leaf and fruit dimensions. Most of the attributes are found better with the application of SAP at high dose (50 g/tree) and with 30% water depletion in soil. The application of SAP in soil led to enhance vegetative growth and fruit growth of acid lime. It also improved water holding capacity of soil, which provides a favourable atmosphere for better growth roots, vegetative growth and ultimately improved yield.

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