Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2017; 6(4): 179-181
Received: 15-05-2017
Accepted: 16-06-2017

Sunita Kumari
Department of Agronomy, Rajasthan College of Agriculture Maharana Pratap University of Agriculture and Technology, Udaipur, Rajasthan, India

NS Solanki
Department of Agronomy, Rajasthan College of Agriculture Maharana Pratap University of Agriculture and Technology, Udaipur, Rajasthan, India

LN Dashora
Department of Agronomy, Rajasthan College of Agriculture Maharana Pratap University of Agriculture and Technology, Udaipur, Rajasthan, India

B Upadhyay
Department of Agronomy, Rajasthan College of Agriculture Maharana Pratap University of Agriculture and Technology, Udaipur, Rajasthan, India

Correspondence
NS Solanki
Department of Agronomy, Rajasthan College of Agriculture Maharana Pratap University of Agriculture and Technology, Udaipur, Rajasthan, India

Effect of super absorbent polymer and plant geometry on growth and productivity of maize (*Zea mays* L.)

Sunita Kumari, NS Solanki, LN Dashora and B Upadhyay

Abstract
A field experiment was conducted during *kharif* 2016 at Instructional Farm, Rajasthan College of Agriculture, Udaipur (Rajasthan).The treatment comprised of four levels of Super absorbent polymer (0, 10, 15 and 20 kg ha^{-1}) and three plant geometry (60 cm x 25 cm, 60 cm x 20 cm and 45 cm x 30 cm) tried in factorial randomised block design replicated three times. The results revealed that the polymer levels 20 kg ha^{-1}recorded significantly higher growth attributes viz., plant height, dry matter accumulation (g plant^{-1}), leaf area index at harvest, relative water content at 60 DAS, and yield attributes viz., number of cobs plant^{-1}, grain rows cob^{-1}, grain cob^{-1}, cob length, 1000- grain weight and grain weight cob^{-1}. Application of 20 kg polymer ha^{-1} gave the maximum grain yield (4006 kg ha^{-1}), stover (5990kg ha^{-1}) and biological yield (9996 kg ha^{-1}). Plant geometry 60 cm x 25 cm recorded higher growth and yield attributes as compared to 60 cm x 20 cm and 45 cm x 30 cm. However, the highest grain yield of 3978 kgha^{-1} was recorded under 60 cm x 20 cm plant geometry. The maximum net return and B C ratio of 35938 and 1.08 were recoded under plant geometry 60 cm x 20 cm.

Keywords: absorbent polymer, plant geometry, maize, *Zea mays*

Introduction
Maize is the third most important cereal crop in India after rice and wheat. Globally, India stands 5th rank in acreage and 8th rank in production of maize. In India, it is grown on 9.07 m ha with the production and productivity of 24.26 mt and 26.76 q ha^{-1}, respectively (Govt. of India, 2014) [2]. Rajasthan ranks first in respect of area, where in this crop occupies 0.91 m ha area with production of 1.46 mt and productivity of 15.97 q ha^{-1} (Govt. of Raj, 2014) [3]. Under rainfed condition during *kharif* season, it suffers from natural calamities such as frequent and heavy rainfall or drought with heavy infestation of diseases and insect-pests. Water is an important life saving natural resource for the crop. It profoundly influences photosynthesis, respiration, absorption, translocation and utilization of mineral nutrient and cell division. The use of soil conditioners like super absorbent polymer (hydrogel) has a great potential to exploit the existing water in soil for agricultural crops by increasing their production. When polymers are incorporated into the soil it is presumed that they retain large quantities of water and nutrients, which are released as required by the plant. Thus, plant growth could be improved with limited water supply (Islam *et al*., 2011a) [4]. The incorporation of super absorbent polymer enhanced seed germination and emergence, crop growth and yield and reduce the irrigation requirement of plants (Islam *et al*., 2011a; Yazdani *et al*., 2007) [4, 12]. Super absorbent polymers can hold 400-1500 g of water per dry gram of hydrogel. The use of super absorbent polymers has a great importance for their role in the increase of water absorption capacity and retention of water shortage condition and the decrease of bad effects of drought stress. Under rainfed condition, crops can better withstand drought condition without moisture stress by using hydrogel.

Plant density is efficient management tool for maximizing grain yield by increasing the capture of solar radiation within the canopy (Monnveux *et al*., 2005) [7]. An optimum plant population for maximum economic yield exists for all crop species and varies with cultivar and environment (Bruns and Abbas, 2005) [1]. Modern maize hybrids tolerate higher plant densities than hybrids used in past (Sangoi *et al.,* 2002) [8] and the use of narrow rows has greater potential to enhance grain yield at crowded stands (Silva *et al*., 2006) [9]. Considering the above facts in mind the present investigation was planned.

Materials and Methods
Field experiment was conducted at Instructional farm, Rajasthan College of Agriculture, Udaipur which is situated at 24º34′ N latitude and 73º42′ E longitude and altitude of 582.50 m above mean sea level. The region falls under agro-climatic zone IVa (Sub- humid Southern

Plain and Aravalli Hills) of Rajasthan. The soil of the experimental field was clay loam in texture, slightly alkaline in reaction (pH 7.9), medium in available nitrogen (250.40 kg ha^{-1}), phosphorus (19.4 kg ha^{-1}) and potassium (260.90 kg ha^{-1}). The experiment consisted of 12 treatment combinations comprising four levels of polymer (0, 10, 15 and 20 kg ha^{-1}) and three plant geometry (60 cm x 25 cm, 60 cm x 20 cm and 45 cm x 30 cm). These treatments were tested in a factorial randomised block design with three replications. As regards application of polymer, as per treatment Super Absorbent Polymer (SAP) @ 10, 15, and 20 kg ha^{-1} was mixed with soil and applied in furrow manually at a depth of 8-10 cm and followed by 3-4 cm of soil layering, thus expose about 5 cm deep furrow for sowing of maize seeds. The maize variety PHEM-2 was sown on 15th July 2016 in furrows using seed rate at the rate 20 kg ha^{-1}.

Results and Discussion

Levels pf polymer: An examination of the data presented in Table 1 revealed that application of 20 kg polymer ha^{-1} recorded maximum plant height at harvest (189.8 cm), dry matter accumulation $plant^{-1}$ at harvest (309.42g), leaf area index at harvest (3.72), relative water content (%) at 60 DAS (89.17), which was significantly superior over rest of levels of polymer. With regards to yield attributes, application of polymer 20 kg ha^{-1} resulted in significantly higher number of cob $plant^{-1}$, grain rowscob^{-1}, number of graincob^{-1}, weight of grain cob^{-1}, 1000- grain weight and shelling percentage as compared to 0 and 15 kg ha^{-1} (Table 1). An improvement in yield contributing characters may be due to increase in growth parameters which are influenced by the application of super absorbent polymer in the soil. Similar results of incorporating super absorbent polymer into the soil on yield have been reported by Sivapalan (2006) [10] in soybean under water stress condition. Islam *et al*. (2011b) [5] also obtained significantly increase in grain yield and 1000-grain weight with the application of polymer 20 kg ha^{-1} as compared to control. The maximum grain yield of 4006 kg ha^{-1} was obtained with the application of polymer 20 kg ha^{-1} which was significantly higher over control by 21.7 per cent but at par with 10 and 15 kg ha^{-1}. Further, application of polymer 15 kg ha^{-1} registered significantly higher grain yield over control by 17.0 per cent. Application of polymer 20 kg ha^{-1} also gave the highest stover yield (5990 kg ha^{-1}) and biological yield (9996 kg ha^{-1}). The higher grain yield with application of polymer 20 kg ha^{-1} might be attributed to improved yield components viz., higher number of cobs $plant^{-1}$, grains rows cob^{-1}, number of grains cob^{-1}, cob length, weight of grains cob^{-1} and 1000-grain weight. Super absorbed polymer stored water and nutrient are released slowly as required by plant to improve growth under limited water supply (Yazdani *et al*. 2007) [12]. Application of super absorbent polymer could conserve different amounts of water in it self thereby increasing the soils capacity for water storage, ensuring more available water; thus the relative water content in leaves as well as plant growth and yield increased.The net return was decreased with successive increase in level of polymer as compared to control (₹ 35689). However, the differences were statically at par. The highest B C ratio of 1.49 was recorded with control which was significantly superior over application of polymer 10, 15 and 20 kg ha^{-1} (Table 2).

Table 1: Effect of polymer and plant geometry on growth and yield attributes of maize

Treatments	Plant height (cm)	Dry matter $plant^{-1}$ (gm)	LAI	RWC (%) of leaves	Cobs $plant^{-1}$	Grain rows cob^{-1}	Grains cob^{-1}	Cob girth (cm)	Cob length (cm)	grain weight cob^{-1} (g)	1000-seed weight (g)	Shelling percentage (%)
Levels of polymer												
Control	165.0	253.38	2.99	83.22	1.01	13.3	291.5	12.7	15.1	76.1	203.6	73.6
10 kg ha^{-1}	176.3	270.09	3.24	86.24	1.11	13.9	304.4	13.0	16.2	78.2	209.8	74.2
15 kg ha^{-1}	183.1	289.42	3.46	88.56	1.12	14.2	309.1	13.1	16.6	82.1	219.8	74.9
20 kg ha^{-1}	189.8	309.42	3.72	89.17	1.12	15.7	311.1	13.2	17.0	84.5	233.8	75.6
S. Em. ±	3.6	10.95	0.09	1.01	0.03	0.3	4.5	0.4	0.5	1.0	1.7	0.4
C. D. (P = 0.05)	10.5	32.12	0.26	2.95	0.08	0.8	13.1	NS	1.4	2.9	4.9	1.1
Plant geometry												
60 cm x 25 cm	173.4	305.45	3.77	87.05	1.13	14.7	314.3	13.4	17.5	83.7	219.6	76.6
60 cm x 20 cm	186.7	251.55	2.97	86.45	1.06	13.5	297.1	12.7	15.2	77.6	213.4	73.0
45 cm x 30 cm	175.5	284.73	3.32	86.89	1.08	14.6	300.6	13.0	16.0	79.4	217.2	74.2
S. Em. ±	3.1	9.48	0.08	0.87	0.02	0.2	3.9	0.3	0.4	0.9	1.4	0.3
C. D. (P = 0.05)	9.1	27.81	0.23	NS	NS	0.7	11.4	NS	1.2	2.5	4.2	1.0

Table 2: Effect of levels of polymer and plant geometry on yields, harvest index, net return and B C ratio of maize

Treatments	GrainYield (kg ha^{-1})	Stover yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)	Net return (₹ ha^{-1})	B C ratio
Levels of polymer						
Control	3292	5084	8376	39.34	35689	1.49
10 kg ha^{-1}	3634	5486	9121	39.87	31501	0.93
15 kg ha^{-1}	3854	5764	9618	40.05	30304	0.78
20 kg ha^{-1}	4006	5990	9996	40.06	28027	0.64
S. Em. ±	128	191	295	0.65	2170	0.07
C. D. (P = 0.05)	377	561	864	NS	NS	0.20
Plant geometry						
60 cm x 25 cm	3484	5239	8723	39.93	27486	0.85
60 cm x 20 cm	3978	5836	9814	40.53	35938	1.08
45 cm x 30 cm	3627	5667	9296	39.03	30716	0.94
S. Em. ±	111	166	255	0.57	1880	0.06
C. D. (P = 0.05)	326	486	748	NS	5513	0.17

Plant geometry: Data presented in Table 1 revealed that plant geometry 60 cm x 20 cm significantly recorded highest dry matter accumulation plant^{-1} and leaf area index at harvest. The data indicate that plant geometry did not influence relative water content at 60 DAS. Plant geometry 60 cm x 25 cm significantly higher in yield attribute viz., grain rows cob^{-1}, number of grain cob^{-1}, weight of grain cob^{-1}, 1000- grain weight and shelling percentage as compared to 45 cm x 30 cm and 60 cm x 25 cm (Table 1). The plant geometry 60 cm x 20 cm recorded significantly higher grain yield (3978 kg ha^{-1}) over to 60 cm x 25 and 45 cm x 30 cm by 14.1 and 9.7 per cent, respectively. The plant geometry 60 cm x 20 cm recorded significantly higher stover yield (5836 kg ha^{-1}) and biological yield (9814 kg ha^{-1}) over 60 cm x 25 cm (Table 2). Mutual shading due increased population might have reduced the availability of light within the crop canopy and accelerated the elongation at lower internodes resulting into increased plant height. The higher maize yield with 60 cm x 20 cm may be attributed to increase in the number of plant per unit area which leads to more number of cobs per unit area, the results of which leads to more number of cobs per unit area. The results are in line with the finding of Maddonni *et al*. (2006) [6] in maize and Thavaprakaash *et al*. (2005) [11] in baby corn. Data in Table 2 showed that the highest net return of ₹ 35938 ha^{-1} were obtained at 60 cm x 20 cm plant geometry which gave significantly higher net return by ₹ 8452 ha^{-1} over 60 cm x 25 cm plant geometry but at par with 45 cm x 30 cm (₹ 30716). Plant geometry 60 cm x 20 cm gave significantly higher B C ratio of 1.08 over 60 cm x 25 cm plant geometry (0.85), but at par with 45 cm x 30 cm (0.94).

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