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Growth and yield of rainfed maize as influenced by application of super absorbent polymer and Pongamia leaf mulching

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Abstract
A field experiment was conducted to study the growth and yield of rainfed maize as influenced by the application of superabsorbent polymer and pongamia leaf mulch at Zonal Agricultural and Horticultural Research Station, Babbur Farm, Hiriyur, Karnataka during *Kharif* 2017. The superabsorbent polymer as Pusa hydrogel or commercially available hydrogel at 2.5 and 5.0 kg ha^{-1}and pongamia leaf mulch at 4.0 t ha^{-1}alone and their combinations were set as treatments. The results of the study showed that soil application of commercial hydrogel @ 5.0 kg ha^{-1}+ mulching with pongamia green leaf @ 4.0 t ha^{-1}gave maximum grain yield (93.20q ha^{-1}), stover yield (117.14 q ha^{-1}) compared to rest of the treatments. Similarly, 100 grain weight (46.79 g), cob length (18.87 cm), cob girth (14.92 cm), number of grains per cob (507.73), average AGR (2.65), average CGR (18.61) and maximum LAI (4.71) were also higher. Next best treatment is found to be soil application of pusa hydrogel @ 5.0 kg ha^{-1}+ mulching with pongamia green leaf @ 4.0 t ha^{-1}. From the above results, it can be inferred that soil application of hydrogel with pongamia leaf mulch may be a significant practice to increase the yield of maize under rainfed conditions.

Keywords: drought, yield, maize, hydrogel, leaf mulch

Introduction
Rainfed farming is the backbone of Indian agriculture, as large areas of cultivated land are rainfed. Drought is a natural disaster which causes the most significant loss in the world and has the most substantial impacts of all the natural disasters. The drought had a considerable effect on socio-economic, agricultural and environmental aspects.

Drought is a frequent phenomenon in India and affected areas are mainly confined to the Peninsular and Western parts of the country and of the minor scale in few pockets of the central, eastern and northern regions. Out of 329.8 m ha of total geographical area in India, about 107 m ha of lands are subjected to different degrees of water stress and drought conditions. More than 100 districts spread over 13 states of India have been identified as drought-prone districts. Hence characterization of drought regarding its frequency and severity play an essential role in minimizing the risk associated with drought. Drought characterization enables drought warning and drought risk analysis, which allow for improved preparation and contingency crop planning.

Maize (*Zea mays* L.) is a cereal grain called "queen of cereals" is the third most important cereal crop in India after rice and wheat. In India, it is growing in an area of 8.69 m ha and production of 21.81 mt with the average productivity of 2509 kg ha^{-1}. Karnataka is one of the major producers of maize with an area of 1.18 m ha and a production of 3.27 mt with the productivity of 2773 kg ha^{-1} (Anon., 2016) [1]. Majority of the maize in Karnataka is grown under rainfed conditions, and the occurrence of drought limits the productivity during different growth stages.

Premier institutes like CRIDA of ICAR have developed several drought management options from watershed level to individual crop. Among the several drought management options, use of hydrogel or locally available mulching materials found to be user eco-friendly and cost-effective.

The superabsorbent polymer or hydrogel is water retaining, cross-linked hydrophilic, biodegradable amorphous polymer which can absorb and keep water at least 400 times of its original weight and make at least 95 per cent of stored water available for crop absorption

(Johnson and Veltkamp, 1985) [9]. These synthetic polymers found in the form of crystals and available under several trade names *viz*., super absorbent, pusa hydrogel, commercial hydrogel are collectively called hydrogel. Pusa hydrogel is a novel semi-synthetic superabsorbent polymer developed by the Indian Agricultural Research Institute. Hydrogels are safe and non-toxic and it will finally decompose to carbon dioxide, water and ammonia without any residue (Mikkelsen, 1994) [13].

In arid and semiarid regions, use of superabsorbent polymers (SAP) may effectively increase water and fertilizer use efficiency in crops. These polymers after incorporated with soil, 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*. 2011) [7]. Water retention capacity increased for about 171 to 402 per cent when polymers are incorporate in coarse sand (Johnson, 1984) [8]. Karimi reported that addition of a polymer to peat decreased water stress and increased the time to wilt. The incorporation of SAP with soil improved the soil physical properties (El-Amir *et al*. 1993) [4], enhanced seed germination, seedling emergence, crop growth and yield (Yazdani *et al*. 2007) [15] and reduced the irrigation requirement of plants (Blodgett *et al*. 1993) [2]. The use of hydrophilic polymer materials as a regulator of nutrient release was helpful in reducing undesired fertilizer losses while sustaining vigorous plant growth.

Mulching has been proved to be useful material in conserving moisture and enhancing the productivity of maize. Leaf mulch also provides benefit regarding increasing infiltration rate, lowers the soil temperature and improves fertilizer availability and increase crop yield (Dushouyu *et al*., 1995) [3]. Organic mulches resulted in enhanced soil water status and enhanced plant canopy regarding biomass, root growth, leaf area index and grain yield, which subsequently improve water and nitrogen uptake and their use efficiencies with reducing runoff and evaporation losses. The studies made to understand the combined application of superabsorbent polymers with locally available organic mulches were lacking. Apart from this the physiological basis for improvement of yield of crops when applied with SAP and mulching were need to be understood in detail. With the above facts in view, the present investigation is carried out to study the growth and yield of rainfed maize as influenced by the application of superabsorbent polymer and pongamia leaf mulch.

Material and Methods

An experiment was carried out during *Kharif* 2017 at Zonal Agricultural and Horticultural Research Station, Babbur farm, Hiriyur. The station is located at 13° 94' 38" North latitude and 76° 61'61" East longitude, with an altitude of 630 meters above mean sea level (MSL). It comes under Agro-Climatic Region-10 and Central Dry Zone (Zone-IV) of Karnataka. The soil of the experimental site is vertisol with alkaline pH (8.41), low in organic carbon (0.19 %) and available nitrogen (258kg ha^{-1}), medium in available P_2O_5 (35 kg ha^{-1}) and exchangeable K_2O (315 kg ha^{-1}). The experiment consisted of 10 treatments *viz*., Maize with the recommended package (T_1), Maize with soil application of pusa hydrogel @ 2.5 kg ha^{-1}(T_2), Maize with soil application of commercial hydrogel @ 2.5 kg ha^{-1} (T_3), Maize with soil application of pusa hydrogel @ 5.0 kg ha^{-1}(T_4), Maize with soil application of commercial hydrogel @ 5.0 kg ha^{-1} (T_5), T_2 + mulching with pongamia green leaf @ 4.0 t ha^{-1} (T_6), T_3 + mulching with pongamia green leaf @ 4.0 t ha^{-1}(T_7), T_4 +mulching with pongamia green leaf @ 4.0 t ha^{-1} (T_8), T_5 + mulching with pongamia green leaf @ 4.0 t ha^{-1} (T_9) and Maize with mulching with pongamia green leaf @ 4.0 t ha^{-1} (T_{10}). These treatments were tested in a randomized block design with three replications. The plot size of 3.6 m x 3.0 m was used. A basal dose of recommended fertilizers (100:50:25 NPK kg ha^{-1}) was used. The required quantity of hydrogel was applied to the rows at a depth of 8-10 cm before sowing and mixed with soil. A maize hybrid CP-818 was sown in furrows at a spacing of 30 cm between plants and 45 cm between rows. Immediately after sowing pongamia green leaf mulch @ 4 t $ha^{-1}$was applied. Growth indices like maximum LAI, average AGR, average CGR, yield components like cob length, cob girth, number of grains per cob, 100-grain weight and kernel yield and stover yield was recorded from the five randomly selected plants.

The data on growth indices, yield components and yield were subjected to statistical analysis and was done as per the methodology suggested by Gomez and Gomez (1984) [5]. Wherever the treatment differences were significant, the results have been discussed based on critical differences at p=0.05. The treatment differences being significant to have been denoted by '*'. Carl Pearson's correlation coefficient, as well as simple linear regression, was done by using Microsoft Excel by using data analysis add-in module.

Results and Discussion

The growth indices and yield components of maize as influenced by drought management options are presented in Table 1. At 60 DAS, leaf area index differed significantly due to various drought management options. Significantly higher leaf area index was recorded in the treatment receiving soil application of commercial hydrogel @ 5 kg ha^{-1} + mulching with pongamia green leaf @ 4 t ha^{-1} (4.71) which was found to be on par with soil application of pusa hydrogel @ 5.0 kg ha^{-1} + mulching with pongamia green leaf @ 4.0 t ha^{-1} (4.61), soil application of commercial hydrogel @ 2.5 kg ha^{-1} + mulching with pongamia green leaf @ 4.0 t ha^{-1} (4.39), soil application of pusa hydrogel @ 2.5 kg ha^{-1} + mulching with pongamia green leaf @ 4.0 t ha^{-1} (4.31), soil application of commercial hydrogel @ 5.0 kg ha^{-1} (4.21) and soil application of pusa hydrogel @ 5.0 kg ha^{-1} (4.13). The significantly lower leaf area index was recorded in maize with the recommended package (3.09) compared to all other treatments. As the water content of the plant cell decreases, cell shrinks and turgor pressure against cell walls relaxes. This decrease in cell volume resulting from lower turgor pressure subsequently concentrates solutes in cells. Hydrogel increases the turgor pressure inside the cells by maintaining sufficient amount of water as per plant needs and thus causing an increase in leaf area index and other related parameters (Yazdani *et al*., 2007) [15].

The average absolute growth rate was found to be differed due to different drought management options. Significantly higher absolute growth rate (2.65 g $plant^{-1}$ day^{-1}) was observed in soil application of commercial hydrogel @ 5 kg ha^{-1} + mulching with pongamia green leaf @ 4 t ha^{-1} which are superior over maize with the recommended package (1.80 g $plant^{-1}$ day^{-1}) due to increasing in the rate of dry matter accumulation per day.

Average crop growth rate was found to be differed due to different drought management options. Significantly higher crop growth rate (18.61 g m^{-2} day^{-1}) was observed in soil application of commercial hydrogel @ 5 kg ha^{-1} + mulching with pongamia green leaf @ 4 t ha^{-1} which are superior over maize with the recommended package (13.30g m^{-2} day^{-1}). A significant increase in CGR was observed in the soil treated with hydrogel and mulch with pongamia green leaf which. These results conform to the findings of Yazdani *et al*. (2007) [15] in soybean.

The kernel yield of maize crop is the integrated results of many physiological processes. In the present study drought management options significantly influenced the kernel yield of maize. Fig. 1 indicated that soil application of commercial hydrogel @ 5 kg ha^{-1} + mulching with pongamia green leaf @ 4 t ha^{-1} recorded highest kernel yield (93.20 q ha^{-1}) which was significantly higher over rest of the treatments**.** Application of commercial hydrogel alone @ 5 kg ha^{-1} has also recorded yield (75.68 q ha^{-1}) on par with combined application of hydrogel and pongamia leaf mulch. Similar on par yield levels of maize are also observed with application of commercial hydrogel @ 2.5 kg ha^{-1} along with pongamia leaf mulch @ 4 t ha^{-1} (83.51 q ha^{-1}) and application of pusa hydrogel @ 2.5 kg ha^{-1} along with pongamia leaf mulch @ 4 t ha^{-1} (81.11 q ha^{-1}). Significantly lower kernel yield was noticed when maize was grown with the recommended package (64.03 q ha^{-1}). Even though maize crop experienced moisture stress during critical stages like a knee-high stage, tasseling, cob initiation and soft dough stage (grain growth and filling), application of hydrogel @ 5 kg ha^{-1} + mulching with pongamia green leaf @ 4 t ha^{-1} has recorded significantly higher yield. This may be attributed to a reduction in the surface evaporation from the soil due to mulching coupled with supersorbing properties of the hydrogel which absorbs the water and releases it slowly to the growing plants as per the crop needs. The positive effect of super absorbent polymers in increasing the yields was reported by Khadem *et al*. (2010) [11], Gunes *et al*. (2016) [6] and Kumari *et al*. (2017) [12] in maize.

Yield is an integral result of better yield parameters. The higher grain yield with application of hydrogel coupled mulching is attributed to improved yield components *viz.*, higher cob length (18.87 cm), cob girth (14.92 cm), number of rows per cob (17.64), number of kernels per cob (507.73) and 100 kernel weight (46.72 g). This mooted our interest to study the relationship between yields with yield parameters of maize (Fig. 2). There exists highly significant positive correlation of grain yield with yield parameters *viz.*, cob length (0.81**), cob girth (0.80**), number of rows per cob (0.62**), number of grains per cob (0.91**), 100 seed weight (0.90**) and cob dry weight (0.90**). Improvement in yield components was in turn due to improved growth parameters such as higher total dry matter production and distribution in different parts. These results corroborate the findings of Khadem *et al*. (2010) [11].

Similar to the grain yield stover yield in the study also differed significantly due to drought management options. Stover yield of treatment receiving soil application of commercial hydrogel @ 5 kg ha^{-1} + mulching with pongamia green leaf @ 4 t ha^{-1} was significantly higher (117.14 q ha^{-1}) than maize with the recommended package (98.09 q ha^{-1}). This higher straw yield may be attributed to higher dry matter accumulation in vegetative parts. Super absorbing polymers are known to increase the total size of the plant and dry weight by increasing the growth of cells by reducing the moisture stress effects. Lower stover yield of maize with recommended package may be attributed to the reduced size of the photosynthesizing surface which might have caused a reduction in growth due to a shortage of water during important critical growth stages. These consequently reduced the total straw yield production. Similar results were also obtained by Volkmar and Chang (1995) [14] in Barley and Canola.

Table 1: Growth and yield components of maize as influenced by drought management options

Treatments	Maximum LAI	Average AGR (g day^{-1})	Average CGR (g m^{-2} day^{-1})	Cob length (cm)	Cob girth (cm)	Number of kernels	100 grain weight (g)
T1	3.09	1.80	13.30	11.00	10.33	387.47	40.06
T2	3.58	1.91	14.12	12.60	11.77	418.67	41.70
T3	3.73	1.93	14.28	13.01	12.07	425.73	42.33
T4	4.13	2.03	15.02	14.43	13.23	445.47	44.67
T5	4.21	2.07	15.33	14.57	13.48	448.67	44.81
T6	4.31	2.11	15.62	17.23	13.62	472.67	44.84
T7	4.39	2.15	15.92	17.27	14.18	476.00	45.65
T8	4.61	2.43	17.53	18.33	14.27	491.27	46.20
T9	4.71	2.65	18.61	18.87	14.92	507.73	46.79
T10	3.90	1.95	14.42	13.15	12.13	434.13	43.76
F test	*	*	*	*	*	*	*
S. Em ±	0.22	0.04	0.32	0.99	0.87	13.68	1.35
CD (p=0.05)	0.65	0.13	0.95	2.95	2.59	55.68	5.50

Note: Treatment details

T_1: Maize with recommended package

T_2: Maize with soil application of pusa hydrogel@ 2.5 kg ha^{-1}

T_3: Maize with soil application of commercial hydrogel @ 2.5 kg ha^{-1}

T_4: Maize with soil application of pusa hydrogel@ 5.0 kg ha^{-1}

T_5: Maize with soil application of commercial hydrogel @ 5.0 kg ha^{-1}

T_6: T_2 + mulching with pongamia green leaf @ 4.0 t ha^{-1}

T_7: T_3 + mulching with pongamia green leaf @ 4.0 t ha^{-1}

T_8: T_4 + mulching with pongamia green leaf @ 4.0 t ha^{-1}

T_9: T_5 + mulching with pongamia green leaf @ 4.0 t ha^{-1}

T_{10}: Maize with pongamia green leaf @ 4.0 t ha^{-1}

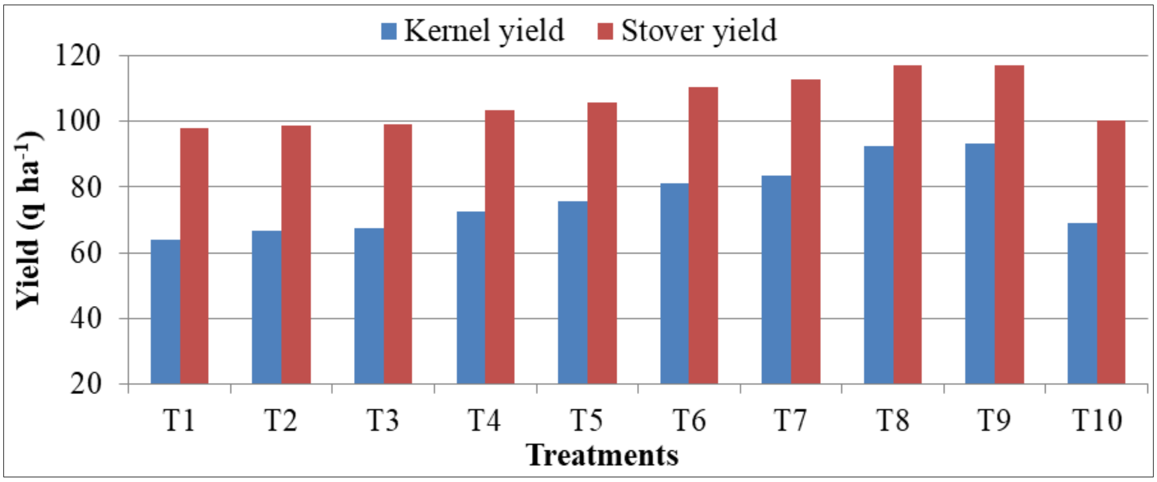

Fig 1: Grain yield and Straw yield of maize as influenced by drought management options

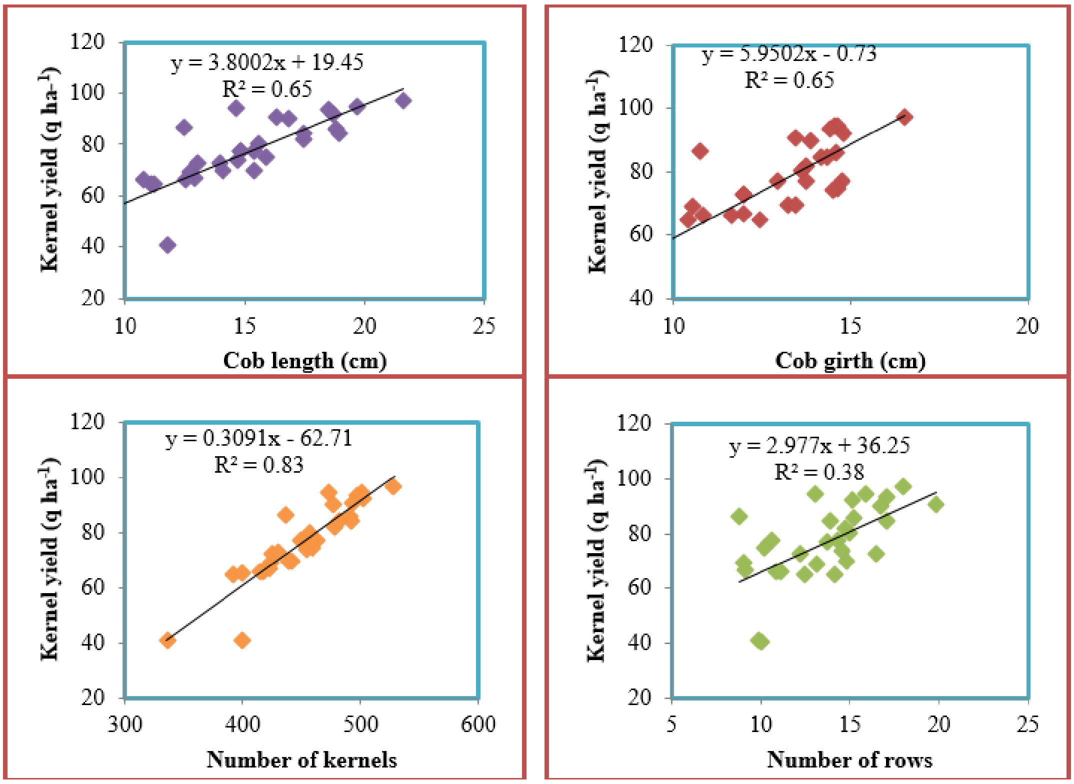

Fig 2: Relationship between kernel yield with (a) Cob length, (b) Cob girth, (c) Number of kernels and (d) Number of rows

Conclusion

The positive effects of hydrogel and pongamia leaf mulching on soil and plant growth resulted in higher maize yield. The soil application of commercial hydrogel at 5.0 kg ha^{-1} + mulching with pongamia green leaf mulch at 4 t ha^{-1} resulted in the highest yield of 93.20qha^{-1} and it was found better than other treatments. From this study, it can be concluded that the combined use of commercial hydrogel at 5.0 kg ha^{-1}with pongamia leaf mulch at 4 t ha^{-1} in crops like maize are viable.

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References

1. Anonymous. Agricultural Statistics at A Glance 2015-16: Directorate of Economics and Statistics, Dac and Fw, 2016, 103-105p.
2. Blodgett AM, Beattis DJ, White JW, Elliot GC. Hydrophilic Polymers and Wetting Agents Affect Absorption and Evaporate Water Loss. Hortic. Sci. 1993; 28:633-635.
3. Dushouyu T, Enping WM, Wqingshan. A Study of the Overall Effect of Straw Mulching and Ploughing In and Techniques for Its Applications. Ningxia J Agri. Forest Sci. Technol. 1995; 5(2):10-14.
4. El-Amir S, Helalia AM, Shawky ME. Effects of Acryhope and Aquastore Polymers on Water Regime and Porosity in Sandy Soils. Egyptian J Soil Sci. 1993; 4:395-404.
5. Gomez KA, Gomez AA. Statistical Procedures for Agricultural Research. John-Wiley and Sons, Inc, New York, 1984, 680p.
6. Gunes A, Nurul Kitir, Metin Turan, Erdal Elkoca, Ertan Yildirim, Nazmiye. Evaluation of Effects of Water-Saving Superabsorbent Polymer on Corn (*Zea Mays* L.)

Yield and Phosphorus Fertilizer Efficiency. Turkish J Agri. Forestry. 2016; 40:365-378.

7. Islam MR, Yuegao Hu, Sishuai Mao, Jinzhu Mao, Egrinya Enejid A, Xuzhang Xue. Effectiveness of a Water Saving Superabsorbent Polymer in Soil Water Conservation for Corn (*Zea Mays* L.) Based On Eco-Physiological Parameters. J Sci. Food Agric. 2011; 91:1998-2005.
8. Johnson MS. The Effect of Gel-Forming Polyacrylamides on Moisture Storage in Sandy Soils. J Sci. Food Agri. 1984; 35:1196-1200.
9. Johnson MS, Veltkamp CJ. Structure And Functioning Of Water Storingagricultural Polyacrylamides. J Sci. Food Agri. 1985; 36:789-793.
10. Karimi A, Noshadi M, Ahmadzadeh M. Effects of Superabsorbent Polymer on Crop, Soil Water and Irrigation Interval. J Sci. Tech. Agri. Natural Res. 2009; 12:415-420.
11. Khadem SA, Galavi M, Ramrodi M, Mousavi SR, Rousta MJ, Andrezvani-Moghadam P. Effect of Animal Manure and Super Absorbent Polymer on Corn Leaf Relative Water Content, Cell Membrane Stability and Leaf Chlorophyll Content Under Dry Condition. Australian J Crop Sci. 2010; 4:642-647.
12. Kumari S, Solanki NS, Dashora LN, Upadhyay B. Effect of Superabsorbent Polymer and Plant Geometry on Growth and Productivity of Maize (*Zea Mays* L.). J Pharmacognosy Phytochem. 2017; 6(4):179-181.
13. Mikkelsen RL. Using Hydrophilic Polymers to Control Nutrient Release. Fertilizer Res. 1994; 38:53-59.
14. Volkmar KM, Chang C. Influence of Hydrophilic Gel Polymers on Water Relations and Growth and Yield of Barley and Canola. Can. J Plant Sci. 1995; 75:605-611.
15. Yazdani F, Traj Alahbadi, Abas Akbari. Impact of Superabsorbent Polymer on Yield and Growth Analysis of Soybean under Drought Stress Condition. Pakistan J Biologic. Sci. 2007; 10(23):4190-4196.