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Effect of treated sewage water and organic manure on growth indices, phenology, cob dimensions and economics of spring maize (*Zea mays* L.) in semi-arid region of Haryana, India

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ABSTRACT

An experiment was conducted during spring 2020 at Student Farm, CCS Haryana Agricultural University Hisar, Haryana to study the effect of single cross hybrids, irrigation sources and organic manures on growth indices, phenology, cob dimensions and economics of maize. The experiment was laid out in split plot design with 3 replications consisting of two single cross hybrids(HQPM-1 and HQPM-5) and two irrigation sources (Canal water and Treated sewage water) in main plots while four levels of organic manure (No manure, 100% RDN though FYM, 100% RDN though vermicompost and 50% RDN though FYM + 50%RDN though vermicompost) in subplots. HQPM-1 had earlier flowering, higher growth rate (absolute, crop and relative), girth and length of cob, gross and net returns in comparison to HQPM-5. Similarly, application of treated sewage water recorded earlier flowering, higher growth rates, cob dimensions and economics as compared to canal water. So the treated water can be used for replacement of conventional water. Highest growth rates, cob dimensions, gross returns and earlier flowering was recorded with application of 100% RDN through vermicompost. However, highest net returns was achieved under 100% RDN through FYM.

Key words: *Cost of cultivation, nitrogen, resource, Silking, Tasselling, Maturity*

Introduction

India is the second largest populous country of the world and this large population base increases the demand for food. Maize (*Zea mays* L.) is third most important crop of India, after rice and wheat. It plays a vital role in maintaining the food security in India. The prevalent rice-wheat cropping system of India has resulted in a number of problems like over-exploitation of underground water, soil degradation, lowering soil fertility etc. Maize can be a replace in this system for the diversification. However, productivity of maize during rainy season is low; spring maize has better prospect owing to higher yield due to less pest incidence, thereby gaining the attention of growers. Water is an important natural resource and its increasing scarcity in arid and semi-arid region of India has led to concern for its management and sustainability. The use of sewage water for agricultural irrigation can reduce the amount of water that needs to be extracted from water resources.

Maize is a C_4 photosynthetic pathway crop which is also known as the "queen of cereal crops" due to its higher genetic yield potential among other members of *Poaceae* family. The normal maize grains have lower quality of protein while the QPM (quality protein maize) has higher amount of tryptophan and lysine in it making it a good quality protein. The introduction of SCH (Single cross hybrid) technology opened the way for genotypic alternatives for the crop diversification. Maize was grown in area of 9.02 m ha with average productivity of 3.07 t ha^{-1} and production of 27.71 m tonnes in India (FAO, 2019). The area, production and productivity of *kharif* maize was 6 thousand hectare, 17 thousand tonnes and 2.83 ton per hectare, respectively in Haryana in 2019-20 (DES, 2021). However, this productivity is highly influenced by choice of cultivar, growing season, irrigation and nutrient management practised and maize productivity can have significant impact on food supply and demands. Different genotypes may behave differently under similar environmental conditions. Therefore it is important to investigate the choice of cultivar selection, alternative option of irrigation water, nutrient source effects and their interaction to optimize the resource use.

Maize is usually considered to require high soil fertility to achieve higher yield. Nitrogen (N) is a major nutrient for maize production as it directly affects the dry matter production by influencing the leaf area and photosynthetic efficiency. N deficiency inhibits the growth of maize and also decreases the shoot to root ratio. Beside this, N deficiency also reduces the radiation use efficiency, radiation interception, dry matter partitioning and growth of reproductive organs. Application of N through synthetic chemical fertilizer leads to leaching and volatilization causing ground water contamination, global warming and decreased soil fertility. Water and N have strong synergistic effects on crop yield (Kaur and Arora, 2018). During past four decades, intensive cultivation including exhaustive high yielding varieties of cereals and decreasing inputs of organic sources have led to severe degradation of soil resulting in the reduction of soil organic matter, fertility and productivity. This gap between nutrient removal and supply through fertilizers is likely to widen further as the food grains and other agricultural commodities needed for the increasing population of the country. Hence,the purpose of this study was to reveal the difference in growth indices, phenology, cob dimension and economics of spring maize under different SCH, irrigation and organic manure sources.

Materials and Methods

The field experiment on maize cropwas conducted during spring 2020 at Student Farm, CCS Haryana Agricultural University Hisar, situated in the semi-arid sub-tropics at 29^{0}10′ N latitude, 75^{0}46′ E longitude and an altitude of 215.2 meter above mean sea level in Haryana state. The soil of experimental site was sandy loam in texture, slightly alkaline in reaction, low in available N, medium in available P and high in available K. The experiment was laid out in split plot design having three replications with two single cross hybrids (HQPM-1 and HQPM-5) and two irrigation sources (CW= Canal Water and TSW= Treated Sewage Water) in main plot while four levels of organic manure (No Manure= No manure or fertilizer, 100% FYM= 100% recommended dose of N through FYM, 100% VC= 100% recommended dose of N through vermicompost and 50-50% Both= 50% of recommended dose of N through FYM and 50% of recommended dose of N through vermicompost) in subplot. According to the nutrient content in the respective organic manure, the amount of organic manure to be applied was calculated for each treatment and applied to soil before sowing of the crop. The seeds were sown 5 cm deep by hand dibbling at the recommended spacing of 60 cm × 20 cm on 26th February, 2020. The crop was raised and managed as per the recommended package and practices of CCS HAU, Hisar. The number of days from sowing to tassel emergence in 50 per cent of the plant within net plot was recorded as day to 50 per cent tasselling. The number of days from sowing to silk emergence in 50 per cent of the plant within net plot was recorded as day to 50 per cent silking. The number of days from sowing to maturity was recorded as the days taken from sowing to when husk of most of the cobs turned yellow and started drying.

Absolute growth rate (AGR) represents the dry weight gained by plant material over an interval of time. It was computed as:

$$AGR=\frac{w_2-w_1}{t_2-t_1}$$

Where, w_1 and w_2 are dry matter accumulation at time t_1 and t_2 respectively. AGR was expressed as g day^{-1}.

Crop growth rate (CGR) is defined as the dry weight gained by plant in a cropped area over a time interval. It was computed as:

$$CGR = \frac{w_2 - w_1}{t_2 - t_1} \times \frac{1}{\text{land area}}$$

Where, w_1 and w_2 are dry matter accumulation at time t_1 and t_2 respectively. CGR was expressed as g m^{-2} day^{-1}.

Relative growth rate (RGR) is the rate of increase in dry weight per unit of existing dry weight over an interval of time. RGR was calculated by using the formula suggested by Blackman (1919) as:

$$RGR = \frac{\log_e w_2 - \log_e w_1}{t_2 - t_1}$$

Where, w_1 and w_2 are dry weight of plant at time t_1 and t_2 respectively. RGR was expressed as g g^{-1} day^{-1}.

Cob girth was measured from ten cobs from each net plot and their average is done and is expressed in cm. The length of ten randomly selected cobs from each net plot was measured from base to tip and average was calculated; which was expressed in cm and named as cob length. The details of economic studies *viz*. cost of cultivation, gross returns and net returns has been worked out on the basis of prevailing market rates at CCS HAU, Hisar during 2020. Cost of cultivation was the total cost involved in executing each treatment and it was expressed in ₹ha^{-1}. Gross returns were the total value of the produce (both grain and straw) for each plot and were expressed in ₹ha^{-1}. Net returns was calculated by subtracting cost of cultivation from the gross returns and was expressed in ₹ha^{-1}. All the experimental data recorded were statistically analysed by the method of analysis of variance (ANOVA) as described by Panse and Sukhatme (1978). The significance of treatment effects was tested with the help of 'F' (variance ratio) test. Appropriate standard errors along with critical differences at (CD at 5%) were recorded for differentiating the treatment effects.

Results and Discussion

Growth indices

Absolute growth rate and Crop growth rate

The data pertaining to absolute growth rate are presented in Table 1. The perusal of data indicates that SCH had a significant effect on AGR. HQPM-1 recorded significantly higher AGR at all the intervals, *i.e.* at 30-60 DAS, 60-90 DAS and 90 DAS – maturity than HQPM-5. It might be due to genetic variation and higher accumulation of dry matter at those stages. Kumar (2016) and Chaudhary *et al*. (2013) also obtained similar results. Irrigation source had non-significant effect on absolute growth rate at all the crop growth intervals. However, TSW recorded numerically higher AGR than CW at all intervals.

Application of organic manure had significant effect on absolute growth rate at 30-60 DAS and 60-90 DAS interval. Application of 100% VC recorded highest AGR being significantly superior over rest of treatments at 30-60 DAS interval. At 60-90 DAS interval, 100% VC recorded highest AGR being statistically at par with 50-50% both and 100% FYM, while significantly higher than no manure. It might be ascribed to the increased growth in organic manure treated plots because of quick availability of nutrients in these plots, which ultimately increased the absolute growth rate. These results are in conformation with Prasad (2019). Organic manure had non-significant effect on absolute growth rate at 90 DAS - maturity interval. However, numerically higher AGR was recoded under 100% VC. Lowest AGR was recoded under no manure at all crop growth intervals.

A trend similar to AGR was observed for the crop growth rate in all the respective SCH, irrigation source and organic manure treatments (Table 1). The abovesaid reasoning in AGR is valid for CGR too.

Relative growth rate

The perusal of data (Table 1) indicates that relative growth rate was non-significantly affected by application of different SCH, irrigation source and organic manure treatments. Numerically, HQPM-1 recorded higher RGR over HQPM-5 at all crop growth intervals, i.e. 30-60 DAS, 60-90 DAS and 90 DAS – at maturity. Application of treated sewage water recorded numerically higher RGR than canal water at all crop growth intervals. Maximum relative growth was achieved under 100% VC while minimum RGR was recorded under no manure at all crop growth intervals.

Phenology

Days to 50 per cent tasseling and 50 per cent silking

The perusal of data presented in Table 2 indicates that days taken to 50% tasseling did not differ significantly due to SCH treatments. However, the genotype HQPM-1 had earlier 50% tasseling than HQPM-5. Irrigation source had no significant effect on days to 50 per cent tasseling. Though, TSW achieved earlier 50 per cent tasseling stage than CW.There was significant effect of organic manure on days to 50 per cent tasseling. The treatment containing 100% VC had significantly earlier 50 per cent tasselling (69.92 DAS) than no manure (72.50 DAS), while remained statistically at par with 50-50% both and 100% FYM. It might be due to quick availability of nutrients especially phosphorous, which plays a crucial role in initiating primordia for the reproductive part of the plants. These results are in consistence with Prasad (2019) and Afe *et al*. (2015). A similar trend was also observed for days to 50% silking.

Days taken to maturity

Data pertaining to days taken to maturity are presented in Table 2. Single cross hybrids had signifi-

Table 1. Effect of treated sewage water and organic manure on the AGR, CGR and RGR of maize

Treatment	At 30-60 DAS			At 60-90 DAS			At 90DAS-maturity		
	AGR	CGR	RGR	AGR	CGR	RGR	AGR	CGR	RGR
Single Cross Hybrid									
HQPM-1	1.28	10.62	0.0424	1.51	12.47	0.0201	1.33	11.02	0.0097
HQPM-5	1.23	10.19	0.0423	1.40	11.56	0.0199	1.07	8.83	0.0092
S.E. (m)±	0.01	0.10	0	0.01	0.11	0	0.02	0.20	0
C.D. (p=0.05)	0.04	0.33	NS	0.05	0.38	NS	0.09	0.70	NS
Irrigation Source									
CW	1.24	10.32	0.0422	1.440	11.88	0.0199	1.19	9.86	0.0094
TSW	1.26	10.48	0.0424	1.474	12.15	0.0201	1.21	9.99	0.0095
S.E. (m)±	0.01	0.01	0	0.015	0.11	0	0.02	0.20	0
C.D. (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Organic Manure									
No manure	0.94	7.85	0.0418	1.01	8.31	0.0188	0.57	4.74	0.0072
100% FYM	1.22	10.14	0.0425	1.42	11.72	0.0201	1.22	10.11	0.0098
100% VC	1.52	12.68	0.0426	1.83	15.17	0.0206	1.62	13.39	0.0105
50-50% Both	1.31	10.94	0.0425	1.55	12.85	0.0204	1.39	11.47	0.0102
S.E. (m)±	0.06	0.55	0.001	0.14	1.21	0.001	0.34	2.87	0.002
C.D. (p=0.05)	0.19	1.60	NS	0.42	3.54	NS	NS	NS	NS

Table 2. Effect of treated sewage water and organic manure on cob dimensions and phenology of maize

Treatment	Cob girth (cm)	Cob length (cm)	Days to		
			50% tasseling	50% silking	Maturity
Single Cross Hybrid					
HQPM-1	3.20	13.88	70.00	73.21	121.46
HQPM-5	3.09	13.46	71.42	73.88	123.58
S.E. (m)±	0.02	0.09	0.47	0.33	0.33
C.D. (p=0.05)	0.06	0.32	NS	NS	1.14
Irrigation Source					
CW	3.10	13.49	70.96	73.75	122.17
TSW	3.19	13.86	70.46	73.33	122.88
S.E. (m)±	0.05	0.09	0.47	0.33	0.33
C.D. (p=0.05)	0.06	0.32	NS	NS	NS
Organic Manure					
No manure	2.60	10.50	72.50	75.50	119.08
100% FYM	3.20	14.50	70.33	73.25	122.58
100% VC	3.50	15.00	69.92	72.58	124.58
50-50% Both	3.30	14.70	70.08	72.83	123.83
S.E. (m)±	0.03	0.21	0.57	0.51	0.82
C.D. (p=0.05)	0.07	0.61	1.66	1.49	2.40

cant effect on days taken to maturity. HQPM-1 took lesser days to maturity (121.46 DAS) than HQPM-5 (123.58 DAS). It might be due to genetic variation. Irrigation source had non-significant effect on days to maturity.

Among different organic manure treatments, application of 100% VC significantly affected days taken to maturity and took maximum number of days to attain maturity which was statistically at par with 50-50% both, 100% FYM and significantly higher than no manure. This might be due to increased fertility levels by continuous availability of nutrients released from organic manure. These results are in agreement with Prasad (2019) and Meena *et al*. (2012). The minimum number of days to maturity was recorded under no manure.

Cob girth and cob length

Data regarding girth and length of cob are presented in Table 2, which indicates that all the treatment *i.e.* single cross hybrid, irrigation source and organic manure had significant effect on cob girth and cob length. HQPM-1 had significantly higher cob girth (3.20 cm) and cob length (13.88) than HQPM-5 (3.09 and 13.46 cm, respectively).This might be due to genetic characteristics in together with higher dry matter causing more efficiency in utilization of energy. Higher cob girth (3.19 cm) and cob length (13.86 cm) was recorded with irrigation by treated sewage water over canal water (3.10 and 13.49 cm, respectively). It might be due to additional nutrient input through TSW. These results are in conformity with Chandrikapure *et al*. (2017) and Alkhamisi (2011).

Among organic manure treatments, 100% VC had highest cob girth (3.50 cm) and cob length (15.00 cm), which was significantly higher than rest of treatments. Minimum cob girth (2.60 cm)and cob length (10.50 cm) was observed under no manure. This might be due to the increased availability of nitrogen in soil by application of organic manure and thus consequently increased cob girth and cob length. These results are in close conformity with Prasad (2019), Gunjal and Chitodkar (2017) and Dash (2010).

Economics

The data pertaining to economics are presented in Table 3. The application of different SCH, irrigation source and organic manure differed markedly with respect to cost of cultivation, gross returns and net returns. Economics of a treatment is vital in deciding the efficiency of that treatment. Single cross hybrids and irrigation source had similar cost of cultivation (60443 ₹ ha^{-1}). HQPM-1 recorded higher gross returns and net returns than HQPM-5. Application of treated sewage water recorded higher gross returns and net returns than canal water. This was due to higher yield in these plots causing higher returns over the cost.

In case of organic manure, highest cost of cultivation was recorded under 100% vermicompost (73000 ₹ ha^{-1}) while lowest cost of cultivation was with no manure (44200 ₹ ha^{-1}). Highest gross returns (138496 ₹ ha^{-1}) was recorded under 100% VC. Highest net returns (72837 ₹ ha^{-1}) was recorded under 100% FYM. It was due to relatively very low cost of FYM than vermicompost. These results are in close conformity with Prasad (2019) and Meena *et al*. (2012). Lowest gross returns and net returns was recorded with no manure.

Based on one year study it may be concluded that

Table 3. Effect of treated sewage water and organic manure on the economics of maize hybrids

Treatment	Cost of cultivation (₹ ha^{-1})	Gross returns (₹ ha^{-1})	Net returns (₹ ha^{-1})
Single Cross Hybrid			
HQPM-1	60443	110387	49943
HQPM-5	60443	104977	44533
Irrigation Source			
CW	60443	106534	46090
TSW	60443	108829	48385
Organic Manure			
No manure	44200	26901	-17298
100% FYM	58725	131562	72837
100% VC	73000	138496	65496
50-50% Both	65850	133767	67917

application of 100% RDN through vermicompost, the single cross hybrid HQPM-1 had earlier flowering, higher growth rate (Absolute, crop and relative), girth and length of cob as compared to HQPM-5 irrespective of irrigation source. However, monetary benefits were higher with application of 100% RDN through FYM. Hence, treated sewage water can be successfully used in replace of conventional irrigation water.

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