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STUDIES ON THERMAL, OPTICAL AND BIO-PHYSICAL BEHAVIOR OF MAIZE HYBRIDS AS INFLUENCED BY PLANT POPULATION AND LEVELS OF FERTILIZATION IN IRRIGATED ECO-SYSTEM

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Abstract

A field experiment was conducted for two consecutive years (2013 and 2014) at Agricultural Research Station, Mudhol located at $16^0$23'56.4'' North latitude, $75^0$6'33'' East longitude and at an altitude of 577.6 meters above mean sea level under assured irrigated ecosystem. Treatments comprises of three maize hybrids (H_1-NK-6240, H_2-Super 900-M and H_3-Arjun), two plant populations (P_1-1, 11, 111 and P_2-83, 333 plants ha^{-1}) and five fertility levels (F_1-$N_{(150)}P_2O_{5(65)}K_2O_{(65)}$, F_2-$N_{(187)}P_2O_{5(81)}K_2O_{(81)}$, F_3-$N_{(225)}P_2O_{5(97)}K_2O_{(97)}$, F_4-$N_{(262)}P_2O_{5(114)}K_2O_{(114)}$ and F5-$N_{(300)}P_2O_{5(130)}K_2O_{(130)}$ kg ha^{-1}). Among the hybrids significantly higher canopy temperature was recorded with Arjun at grain filling stage (29.43 °C) and light transmission ratio at seedling, silking and grain filling state (42.23, 11.34 and 6.32 %, respectively) resultant to significantly lower light absorption at silking and grain filling was associated with former hybrid (86.66 and 93.68%, respectively). Significantly higher leaf area at seedling, silking and grain filling state was higher with NK-6240 (6.44, 47.65 and 53.59 dm^2 plant^{-1}, respectively), leaf area index (0.62, 4.60 and 5.17, respectively) and total dry matter production (6.87, 78.32 and 242.87 g plant^{-1}) and significantly higher grain yield was recorded with NK-6240 (10.14 t ha^{-1}) and was comparable with Super 900-M. Among the plant population higher plant population transmitted lower light at seedling, silking and grain filling stage (39.90, 6.48 and 4.99%, respectively) and absorbed higher amount of light (60.10, 93.52 and 95.01%, respectively). Leaf area per plant (6.75, 47.37 and 52.55 dm^2 plant^{-1}) and total dry matter (6.82, 77.04 and 222.77 g plant^{-1}) was higher with lower plant density and LAI (0.61, 4.59 and 5.26, respectively) and grain yield (9.80 t ha^{-1}) was higher with higher plant population. Among the fertility levels, application of $N_{(150)}P_2O_{5(65)}K_2O_{(65)}$ kg ha^{-1} recorded higher canopy temperature, higher light transmission ratio and lower absorption ratio. In the contrary $N_{(300)}P_2O_{5(130)}K_2O_{(130)}$ kg ha^{-1} recorded higher leaf area per plant (7.59, 50.81 and 57.34 dm^2 plant^{-1}, respectively), leaf area index (0.73, 4.77 and 5.54, respectively), total dry matter production (7.56, 87.58 and 242.03 g plant^{-1}) and grain yield (10.42 t ha^{-1}).

Key words: Canopy temperature, light absorption, light transmission, LAI, maize, grain yield.

Introduction

Though maize was the untouched crop of Indian green revolution, it occupied a pride place among the cereals in India, because it is considered as promising option for diversifying agriculture in both rainfed and irrigated eco-systems. Its adoptability in various cropping system as component crop made it to stand in third position after rice and wheat. Performance of plants depends on their genetic constitution, productivity capacity of soil and climate for their growth and development. The interaction of plant with thermal and optical environment lies with the phenomenon of growth and development (Hemalatha *et al.*, 2013). Maize is one such crop, which dictates the dynamics of soil and environmental anomalies instantly because of its quick response to change in plant population and fertility levels. Plant canopy temperature is an important stress indicator which is often affected by crowding and under fertilization Gollar and Patil (2000). When the plant under stress it bound to absorb infrared rage of electromagnetic spectrum due to lack of reflecting pigment chlorophyll, chlorophyll development again depends on plant crowding and its nutrition, lack of assimilatory pigments having directly control over important bio-physical parameters of plant like leaf area, leaf area index and total dry matter production (Gitelson Anatoly *et al*., 2003). Since, productivity potential of any

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crop dependent trait on sources lode of plant. Hence, to ascertain the exact relationship of soil-plant-atmosphere present field experiment was carried out at Agricultural Research Station, Mudhol Karnataka under assured irrigated condition.

Materials and Methods

A field experiment was conducted during *kharif* 2013 and 2014 at Agriculture Research Station Farm, Mudhol to study the effects of single cross hybrids, plant population and level of fertilization on growth and yield attributes, yield, nutrient use efficiency and economics of maize production.

The experiment was laid out in split-split plot design and was replicated thrice. Three hybrids (H_1-NK-6240, H_2-Super 900-M and H_3-Arjun), two populations (P_1-1, 11, 111 and P_2-83, 333 plants ha^{-1}) and five fertility levels (F_1- $N_{(150)}P_2O_{5(65)}K_2O_{(65)}$ (RDF), $N_{(187)}P_2O_{5(81)}K_2O_{(81)}$ (125 % of RDF), $N_{(225)}P_2O_{5(97)}K_2O_{(97)}$ (150 % of RDF), $N_{(262)}P_2O_{5(114)}K_2O_{(114)}$ (175 % of RDF), $N_{(300)}P_2O_{5(130)}K_2O_{(130)}$ (200 % of RDF) were assigned to main plot, sub-plot and sub-sub plots, respectively.

Well decomposed farm yard manure at the rate of 10 tonnes and 25 kg $ZnSO_4$ and $FeSO_4$ per hectare was applied uniformly over all the treatments and seeds were treated with phosphorus solibilizing bacteria and *Azospirullam* each at the rate of 750 g per hectare. As per the treatments seed rows at 45 cm and 60 cm were opened to accommodate 1, 11, 111 and 83, 333 plants per hectare in sub plots. Inter row spacing of 20 cm was maintained for both the populations. Basal dose of nitrogen (15% of RDN), phosphorous (100% RDP_2O_5), potassium (RDK_2O) and micronutrients were applied at the time of sowing and reaming quantity nitrogen was applied in four splits. The observations on growth and yield were recorded as per the standard procedure and were statistically analyzed as method suggested by Gomez and Gomez (1984). Canopy temperature was measured by using infrared thermometer at middle of the crop canopy inside the net plot area the observations were made at bright sunshine hours and expressed as degree centigrade. The light intensity was measured with lux meter both the above and below the canopy at bright sunshine hours at different growth stages at different corners of the net plot area and values were averaged. Light transmission ratio (LTR) and light absorption ratios (LAR) were calculated by following formula.

$$\mathrm{LTR}(\%) = \frac{1}{I_0} \times 100$$

Table A : Monthly meteorological data for the year 2013 and 2014 against normal for 10 years (2002-2012) at ARS, Mudhol, Bagalkot (Karnataka).

Months	Rainfall (mm)			Monthly maximum temperature (°C)			Monthly minimum temperature (°C)			Relative humidity at 07:17 hours (%)			Relative humidity at 14:17 hours (%)		
	Normal	2013	2014	Normal	2013	2014	Normal	2013	2014	Normal	2013	2014	Normal	2013	2014
January	2.0	0.7	0.4	28.57	31.74	29.06	14.42	14.49	14.73	78.20	74.58	75.15	55.10	63.12	58.87
February	1.0	9.2	8.8	31.58	32.70	32.68	17.28	15.16	15.53	73.94	66.96	63.15	47.56	52.93	39.96
March	6.0	1.2	35.3	34.88	36.19	36.39	19.58	18.77	19.83	74.53	65.61	62.65	44.91	47.09	34.57
April	25.0	33.1	37.6	35.83	37.60	38.75	23.08	20.00	23.73	80.26	78.00	76.12	52.10	51.00	29.22
May	63.0	51.4	78.7	37.08	37.90	37.79	23.88	21.90	24.14	83.00	84.00	81.12	50.50	66.00	43.79
June	71.0	196.0	84.4	31.97	31.90	34.33	22.93	19.60	23.13	87.99	87.00	85.64	65.96	68.00	61.53
July	67.0	215.7	238.7	29.40	29.70	29.58	22.40	19.30	22.23	91.71	89.00	89.74	74.22	65.00	72.88
August	59.0	143.8	207.9	28.28	30.70	28.09	21.87	19.00	21.51	90.71	86.00	88.15	75.13	68.00	81.68
September	132.0	181.1	30.6	29.40	30.20	27.78	21.69	18.30	20.75	92.98	82.30	84.12	74.14	59.00	80.87
October	95.0	91.9	21.12	29.70	31.14	29.00	21.22	18.54	19.51	87.13	83.96	81.12	68.23	68.61	74.24
November	31.0	0.1	2.2	28.92	30.68	28.30	18.06	16.66	16.13	78.54	87.73	84.00	58.79	64.16	68.85
December	6.0	0.0	0.0	29.43	30.83	29.98	15.18	12.50	11.12	77.09	82.43	80.12	55.01	60.48	55.113
Total/mean	**588.0**	**924.2**	**745.7**	**31.25**	**32.61**	**32.60**	**20.13**	**17.85**	**19.36**	**83.01**	**80.63**	**79.25**	**60.14**	**61.12**	**58.46**

Table 1 : Canopy temperature (°C), light transmission and light absorption ratio of maize as influenced by hybrids, plant population and levels of fertilization (pooled data of two years).

Treatments	Canopy temperature (°C)			Light transmission ratio (%)			Light absorption ratio (%)		
	Seedling	Silking	Grain filling	Seedling	Silking	Grain filling	Seedling	Silking	Grain filling
Maize hybrids (H)									
H_1-NK-6240	26.51a	26.85a	29.15b	42.49a	10.57b	5.33b	57.51a	88.43b	94.67b
H_2-Super 900-M	26.35a	26.81a	29.11b	40.80a	7.85c	4.59c	59.20a	92.15a	95.41a
H_3-Arjun	26.30a	26.87a	29.43a	42.23a	11.34a	6.32a	57.77a	86.66c	93.68c
S. Em.±	**0.19**	**0.06**	**0.07**	**10.93**	**0.19**	**0.13**	**1.29**	**0.19**	**0.13**
Plant population ha^{-1} (P)									
P_1-1, 11, 111	26.48a	26.66a	29.06b	39.90b	6.48b	4.99b	60.10a	93.52a	95.01a
P_2-83, 333	26.30a	27.03a	29.40a	43.79a	13.36a	5.83a	56.21b	86.64b	94.17b
S. Em.±	**0.19**	**0.19**	**0.04**	**0.82**	**0.21**	**0.08**	**0.82**	**0.21**	**0.08**
Fertility levels kg ha^{-1} (F)									
F_1-$N_{(150)}P_2O_{5(65)}K_2O_{(65)}$	26.43a	27.60a	29.59a	47.33a	13.55a	6.26a	52.67c	86.45d	93.74c
F_2- $N_{(187)}P_2O_{5(81)}K_2O_{(81)}$	26.45a	27.14b	29.41a	44.31ab	11.04b	5.87a	55.69bc	88.96c	94.13c
F_3- $N_{(225)}P_2O_{5(97)}K_2O_{(97)}$	26.37a	26.59c	29.47a	43.13b	9.18c	5.27b	56.87b	90.82b	94.73b
F_4- $N_{(262)}$ $P_2O_{5(114)}$ $K_2O_{(114)}$	26.39a	26.53c	28.99b	38.16c	8.27cd	5.01bc	61.84a	91.73ab	94.99ab
F_5- $N_{(300)}$ $P_2O_{5(130)}$ $K_2O_{(130)}$	26.31a	26.36c	28.70c	36.28c	7.56d	4.65c	63.72a	92.44a	95.35a
S. Em.±	**0.07**	**0.14**	**0.06**	**1.08**	**0.39**	**0.16**	**1.08**	**0.39**	**0.16**
Interactions (H × P × F)									
$H_1P_1F_1$	26.77a	27.81ab	29.15f-i	45.34a-e	9.24e-i	5.19e-k	54.66e-i	90.76d-h	94.81a-g
$H_1P_1F_2$	26.64a	26.98a-h	29.31c-h	44.18a-f	7.05h-l	4.63h-k	55.82d-i	92.95a-e	95.37a-e
$H_1P_1F_3$	26.45a	26.41d-h	29.22d-h	41.80b-i	5.85j-l	4.59h-k	58.20a-h	94.15a-c	95.41a-d
$H_1P_1F_4$	26.48a	26.14gh	28.85h-j	36.80e-i	5.66kl	4.60h-k	63.20a-e	94.34ab	95.40a-d
$H_1P_1F_5$	26.50a	26.02h	28.28kl	35.11f-i	5.50kl	4.63h-k	64.89a-d	94.50ab	95.37a-e
$H_1P_2F_1$	26.57a	27.68a-c	29.59b-f	50.57ab	19.38ab	6.75bc	49.43hi	80.62kl	93.25ij
$H_1P_2F_2$	26.25a	27.38a-f	29.38c-g	42.60a-h	16.53bc	6.62b-d	57.40b-i	83.47jk	93.38h-j
$H_1P_2F_3$	26.42a	26.73a-h	29.23d-h	45.60a-e	12.33de	5.66c-i	54.40e-i	87.67hi	94.34c-i
$H_1P_2F_4$	26.57a	26.74a-h	29.20d-h	41.80b-i	12.83d	5.46d-j	58.20a-h	87.17i	94.54b-h
$H_1P_2F_5$	26.43a	26.64b-h	29.26d-h	41.15c-i	11.36d-f	5.12f-k	58.85a-g	88.64g-i	94.88a-f
$H_2P_1F_1$	26.30a	27.87a	29.68b-d	42.83a-h	7.38g-l	4.63h-k	57.17b-i	92.62a-f	95.37a-e
$H_2P_1F_2$	26.45a	27.12a-h	29.37c-g	42.05a-i	5.07l	4.59h-k	57.95a-i	94.93a	95.41a-d
$H_2P_1F_3$	26.34a	26.36e-h	29.20d-h	38.54d-i	4.18l	4.37i-k	61.46a-f	95.82a	95.63a-c
$H_2P_1F_4$	26.58a	26.25f-h	28.60j-l	36.09f-i	4.95l	4.31jk	63.91a-d	95.05a	95.69ab
$H_2P_1F_5$	26.44a	26.12gh	28.18l	33.29i	4.53l	3.86k	66.71a	95.47a	96.14a
$H_2P_2F_1$	26.32a	27.45a-e	29.50c-g	48.26a-c	12.95d	5.68c-i	51.74g-i	87.05i	94.32c-i
$H_2P_2F_2$	26.50a	27.17a-g	29.56b-f	43.21a-g	10.88d-f	5.01g-k	56.79c-i	89.12g-i	94.99a-e
$H_2P_2F_3$	26.32a	26.65b-h	29.99ab	47.21a-d	10.44d-g	4.69g-k	52.79f-i	89.56f-i	95.31a-e
$H_2P_2F_4$	26.24a	26.56c-h	28.71i-k	39.22c-i	9.63e-h	4.48i-k	60.78a-g	90.37e-h	95.52a-c
$H_2P_2F_5$	26.06a	26.59c-h	28.34kl	37.28e-i	8.45f-k	4.31jk	62.72a-e	91.55b-g	95.69ab
$H_3P_1F_1$	26.46a	27.21a-g	29.35c-g	45.90a-e	10.83d-f	7.11ab	54.10e-i	89.17g-i	92.89jk
$H_3P_1F_2$	26.60a	26.91a-g	29.20d-h	45.70a-e	8.89f-j	6.34b-f	54.30e-i	91.11c-g	93.66f-j
$H_3P_1F_3$	26.61a	26.41d-h	29.38c-g	42.19a-i	6.49i-l	5.87b-h	57.81a-i	93.51a-d	94.13d-j
$H_3P_1F_4$	26.29a	26.14gh	29.18e-h	34.55g-i	6.13i-l	5.28e-j	65.45a-c	93.87a-d	94.72b-g
$H_3P_1F_5$	26.25a	26.10gh	29.02g-j	34.08hi	5.41kl	4.89g-k	65.92ab	94.59ab	95.11a-e
$H_3P_2F_1$	26.14a	27.57a-d	30.25a	51.07a	21.50a	8.17a	48.93i	78.50l	91.83k

Table 1 continued...

Table 1 continued...

$H_3P_2F_2$	26.27a	27.28a-g	29.66b-e	48.09a-c	17.82bc	8.02a	51.91g-i	82.18jk	91.98k
$H_3P_2F_3$	26.08a	27.01a-h	29.77bc	43.45a-g	15.79c	6.46b-e	56.55c-i	84.21j	93.54g-j
$H_3P_2F_4$	26.20a	27.34a-f	29.37c-g	40.48c-i	10.44d-g	5.95b-g	59.52a-g	89.56f-i	94.05e-j
$H_3P_2F_5$	26.16a	26.71a-h	29.12f-i	36.80e-i	10.10d-h	5.08f-k	63.20a-e	89.90e-i	94.92a-f
S. Em.±	**0.21**	**0.34**	**0.14**	**2.64**	**0.96**	**0.39**	**2.64**	**0.96**	**0.39**
CV (%)	**1.08**	**2.20**	**3.84**	**10.93**	**16.73**	**12.35**	**7.86**	**2.84**	**2.70**

Means followed by the same letter (s) within a column are not significantly differed from each other at 5 per cent probability level

Table 2 : Leaf area (dm^2 $plant^{-1}$), leaf area index, total dry matter production (g $plant^{-1}$), grain yield (t ha^{-1}) of maize as influenced by hybrids, plant population and levels of fertilization (pooled data of two years).

Treatments	**Leaf area dm^2 $plant^{-1}$**			**Leaf area index**			**Total dry matter production**			**Grain yield**
	Seedling	**Silking**	**Grain filling**	**Seedling**	**Silking**	**Grain filling**	**Seedling**	**Silking**	**Grain filling**	
Maize hybrids (H)										
H_1-NK-6240	6.44a	47.65a	53.59a	0.62a	4.60a	5.17a	6.87a	78.32a	242.87a	10.14a
H_2-Super 900-M	6.40a	45.72a	53.85a	0.61a	4.40ab	5.20a	6.75a	77.67a	234.18a	9.89a
H_3-Arjun	5.58a	39.62b	42.34b	0.53a	3.65b	4.08b	6.15b	67.40b	177.34b	7.59b
S. Em.±	**0.33**	**1.63**	**0.96**	**0.03**	**0.17**	**0.10**	**0.16**	**1.84**	**4.95**	**0.16**
Plant population ha^{-1} (P)										
P_1-1, 11, 111	5.53b	41.29b	47.31b	0.61a	4.59a	5.26a	6.36b	71.89b	213.49b	9.80a
P_2-83, 333	6.75a	47.37a	52.55a	0.56b	3.85b	4.38b	6.82a	77.04a	222.77a	8.61b
S. Em.±	**0.12**	**0.47**	**0.70**	**0.01**	**0.08**	**0.06**	**0.11**	**1.58**	**1.51**	**0.15**
Fertility levels kg ha^{-1} (F)										
F_1-$N_{(150)}P_2O_{5(65)}K_2O_{(65)}$	5.01	38.57	41.73	0.48d	3.71d	4.02e	5.53d	60.80d	189.07d	7.38
F_2- $N_{(187)}P_2O_{5(81)}K_2O_{(81)}$	5.55	40.45	45.68	0.53cd	3.90d	4.41d	6.18c	68.25c	206.98c	8.43
F_3- $N_{(225)}P_2O_{5(97)}K_2O_{(97)}$	6.02	44.04	49.93	0.58bc	4.23c	4.81c	6.57bc	75.09b	219.66b	9.69
F_4- $N_{(262)}P_2O_{5(114)}K_2O_{(114)}$	6.53	47.78	54.96	0.62b	4.48b	5.30b	7.10ab	80.59b	232.92a	10.12
F_5- $N_{(300)}P_2O_{5(130)}K_2O_{(130)}$	7.59	50.81	57.34	0.73a	4.77a	5.54a	7.56a	87.58a	242.03a	10.42
S. Em.±	**0.19**	**0.88**	**0.76**	**0.02**	**0.12**	**0.07**	**0.21**	**2.39**	**3.74**	**0.22**
Interactions (H x P x F)										
$H_1P_1F_1$	4.89	39.35	40.58	0.54d-f	4.37d-h	4.51h-k	5.32ef	59.52gh	209.37f-i	8.73
$H_1P_1F_2$	5.15	41.96	46.09	0.57c-f	4.66c-f	5.12c-g	6.17a-f	68.03d-h	226.28c-h	9.70
$H_1P_1F_3$	5.62	45.14	49.99	0.62b-f	5.02b-d	5.55cd	6.63a-e	74.98b-g	240.16a-f	11.57
$H_1P_1F_4$	6.26	47.12	57.09	0.70a-e	5.24a-c	6.34ab	7.36a-d	82.00a-f	255.89a-c	11.92
$H_1P_1F_5$	7.74	51.82	59.53	**0.86a**	**5.76a**	6.61ab	7.80ab	86.50a-d	260.99ab	12.14
$H_1P_2F_1$	5.49	43.55	47.84	0.46f	3.63j-l	3.99k-m	5.92c-f	67.56d-h	219.64e-h	7.90
$H_1P_2F_2$	6.04	44.98	52.42	0.50ef	3.75g-l	4.37h-l	6.94a-e	78.02a-g	234.74b-g	8.64
$H_1P_2F_3$	7.09	50.15	56.43	0.59c-f	4.18e-j	4.70g-j	7.40a-d	82.53a-f	247.35a-e	9.98
$H_1P_2F_4$	7.36	55.00	61.80	0.61b-f	4.58c-f	5.15c-g	7.33a-d	89.30a-c	263.47ab	10.01
$H_1P_2F_5$	8.73	**57.49**	**64.16**	0.73a-d	4.79c-e	5.35c-e	7.79ab	95.54a	270.79a	10.80
$H_2P_1F_1$	4.57	37.01	42.58	0.51ef	4.11e-j	4.73f-j	5.65d-f	62.31f-h	206.35g-i	8.90
$H_2P_1F_2$	5.38	39.10	47.78	0.60c-f	4.34d-i	5.31c-f	5.98c-f	67.72d-h	222.48d-h	10.22
$H_2P_1F_3$	5.44	41.60	50.36	0.60c-f	4.62c-f	5.60c	6.29a-f	77.21a-g	233.50b-g	11.53
$H_2P_1F_4$	6.12	46.83	55.25	0.68a-e	5.20a-c	6.14b	7.29a-d	83.31a-e	245.47a-e	11.67
$H_2P_1F_5$	7.17	49.42	60.36	0.80ab	5.49ab	**6.71a**	7.80ab	94.75ab	251.17a-d	11.83
$H_2P_2F_1$	5.53	42.68	47.58	0.46f	3.56j-l	3.96k-m	5.87c-f	65.85e-h	212.78f-i	7.03
$H_2P_2F_2$	6.18	43.57	51.66	0.51ef	3.63j-l	4.30i-m	6.50a-e	73.58c-g	227.10c-h	8.21

Table 2 continued...

Table 2 continued...

$H_2P_2F_3$	6.89	48.90	56.52	0.57c-f	4.07f-j	4.71f-j	6.82a-e	80.55a-f	238.90b-f	9.46
$H_2P_2F_4$	7.79	52.30	62.28	0.65b-f	4.36d-i	5.19c-g	7.45a-c	81.31a-f	247.04a-e	10.07
$H_2P_2F_5$	**8.99**	55.76	64.16	0.75a-c	4.65c-f	5.35c-e	7.88a	89.29a-c	257.03a-c	9.98
$H_3P_1F_1$	4.17	31.41	33.49	0.46f	3.49j-l	3.72mn	4.71f	50.17h	137.24l	6.75
$H_3P_1F_2$	4.50	32.97	37.48	0.50ef	3.66i-l	4.16j-m	5.43ef	59.08gh	157.27kl	7.00
$H_3P_1F_3$	4.98	34.00	40.62	0.55d-f	3.78g-l	4.51h-k	5.80c-f	65.64e-h	170.31jk	7.47
$H_3P_1F_4$	5.07	39.71	43.74	0.56c-f	4.41d-g	4.86e-i	6.43a-f	70.04c-h	186.80ij	8.56
$H_3P_1F_5$	5.88	41.92	44.69	0.65b-f	4.66c-f	4.97d-h	6.73a-e	76.25a-g	199.03h-j	9.04
$H_3P_2F_1$	5.45	37.43	38.30	0.45f	3.12l	3.19n	5.72c-f	59.38gh	149.04kl	4.97
$H_3P_2F_2$	6.03	40.15	38.65	0.50ef	3.35kl	3.22n	6.07b-f	63.08e-h	173.99jk	6.83
$H_3P_2F_3$	6.12	44.43	45.67	0.51ef	3.70h-l	3.81lm	6.48a-e	69.63c-h	187.72ij	8.11
$H_3P_2F_4$	6.58	45.73	49.62	0.55d-f	3.07g-l	4.14j-m	6.75a-e	77.57a-g	198.83h-j	8.51
$H_3P_2F_5$	7.04	48.42	51.12	0.59c-f	3.27f-k	4.26i-m	7.33a-d	83.14a-e	213.17f-i	8.70
S. Em.±	**0.46**	**2.16**	**1.85**	**0.05**	**0.29**	**0.18**	**0.51**	**5.86**	**9.16**	**0.55**
CV (%)	**12.91**	**8.42**	**9.43**	**13.74**	**11.85**	**6.56**	**13.30**	**13.62**	**7.27**	**10.27**

Means followed by the same letter (s) within a column are not significantly differed from each other at 5 per cent probability level.

LAR(%) = 100 – LTR

I is the light intensity beneath the canopy, I_0 is the light intensity above the canopy.

Results and Discussion

Thermal behavior of maize hybrids as influenced by plant population and fertility levels

The thermal characteristics of maize hybrids under varied plant population and fertility levels are presented in the table 2. Among the hybrids, significant deference for degree of hotness or coldness was observed only at grain filling stage. Arjun recorded significantly higher canopy temperature at grain filling stage (29.43 ^{O}C) over others. Among the hybrids studied, Arjun was relatively short duration hybrid when compared to NK-6240 and Super 900-M, at terminal phases of crop life cycle crop canopy resembles the temperature of outer environment due to lack of green foliage. Genotypic response to temperature earlier reported by (Girijesh *et al*., 2011). Between the plant population, lower plant population (83, 333 plants ha^{-1}) recorded significantly higher canopy temperature (29.40 ^{O}C). It could be due to in wider inter row better air circulation leads to exchange of gases from surrounding atmosphere resulted in resemblance of outside canopy temperature. These findings are in the line of Timmegouda (2012). Among the fertility levels, application of $N_{(150)}P_2O_{5(65)}K_2O_{(65)}$ kg ha^{-1} recorded higher canopy temperature over rest of the fertility levels at silking and grain filling stage (27.60 and 29.59 ^{O}C, respectively). However, fertility levels F_2, F_3 were on par with former fertility levels. It could be due to under lower fertility levels improper development of chlorophyll leads to chloratic leaves might have absorbed higher amount of infrared region of electromagnetic spectrum, which was supposed to reflect has increased the temperature plant of plant.

Optical behavior of maize hybrids as influenced by plant population and fertility levels

The optical characteristics of maize hybrids as influenced by plant population and fertility levels are presented tin table 1. Among the hybrids, Arjun has transmitted significantly higher quantity of light at all the stages at seedling, silking and at cob maturity stage (42.23, 11.34 and 6.32%, respectively) over others. In the contrary significantly lowest light absorption also recorded with same hybrids and was obvious. Significantly higher light absorption ratio was registered with Super 900-M at seedling, silking and at cob maturity stage (59.20, 92.15 and 95.41%, respectively). This result was conformity by Sharma *et al.* (200). The higher light absorption rate was traced back to the higher leafiness per plant and leaf area index recorded with Super 900-M (table 2). Higher leaf area index is a desirable trait to achieve higher radiation interception around silking and grain filling stage, which directly takes part in accumulation of dry matter in sink apart from remobilization from various plant parts (Mani *et al*., 2013). Because of higher leaf area and leaf area index NK-6240 and Super 900-M have produced higher amount of dry matter and was ultimately reflected in higher grain yield (table 2). Between the planting density higher plant density recorded lower canopy temperature due to overcrowding of leafs coupled with abstraction to air circulation from external hot environment resulted in to humid canopy attributed to lower canopy temperature.

Further, leaf area per plant and total dry matter was higher with lower plant density could be due to less interplant competition for growth resources at lower plant density. Higher leaf area index ascribed to higher light absorption ratio at higher plant density (table 2). Variation in grain yield could be mainly due higher number of reproductive units (cob) harvested at higher plant density Nagaraju (2005). Among the fertility levels application of $N_{(300)}P_2O_{5(130)}K_2O_{(130)}$ kg ha^{-1} intercepted higher amount of incident light at seedling, silking and at cob maturity stage (63.72, 92.44 and 95.35%, respectively) an account of lower light transmission (36.28, 7.56 and 4.65%, respectively) over rest of the fertility levels (table 2). It could be due to higher leaf area per ground area at higher plant density. Effective harvest of solar energy at higher fertility levels resulted in higher total dry matter production and grain yield.

Conclusion

Cultivation of NK-6240 or Super 900-M at 1, 11, 111 plants ha^{-1} coupled with application of $N_{(300)}P_2O_{5(130)}K_2O_{(130)}$ kg ha^{-1} resulted in significantly higher amount of solar radiation can be harvested under irrigated ecosystem.

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