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HIGH DENSITY PLANTING FOR MAXIMIZING AND OPTIMIZING LEAF PRODUCTIVITY IN DRY AND SEMI DRY ZONES OF FLUE-CURED TOBACCO GROWING REGIONS IN KLS

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FCV tobacco is an important commercial crop under rainfed farming in Southern Transitional Zone of Karnataka in KLS. Leaf being the essential economic part in tobacco, the number of leaves per plant, leaf area Index and net leaf dry matter production per unit area are the deciding factors in realizing higher productivity. Drought/moisture stress can substantially decrease the number of leaves, leaf thickness and expansion of individual leaf resulting in lower productivity and poor quality. Nearly two thirds of the tobacco growing areas in KLS falling under dry and semi-dry regions have been periodically experiencing drought/moisture stress severely affecting the sustainable productivity and quality. Field Experiments and large scale location trails were conducted during 2014 to 2018 seasons with four levels of plant densities (18,181, 22,222, 24,691 and 31,250 plants/ha) adopting spacing of 100 x 55 cm (Control), 90 x 50 cm, 90 x 45 cm and 80 x 40 cm respectively, in the popular variety Kanchan in KLS. The study revealed significant increase in cured lead productivity (11-16%) at higher planting density especially in low and medium rainfall zones. There were no perceptual changes in the cured leaf quality characteristics like nicotine, sugars and chlorides and were in normal desired range. High density planting following crop geometry of 90 x 50 cm may be recommended as one of the drought mitigating and climate resilient practices to optimize and stabilize the cured leaf productivity especially in low rainfall and poor fertile dry and semi dry zones of KLS.

INTRODUCTION

FCV tobacco is an important commercial crop grown under rainfed farming on red sandy to sandy loam soils (Alfisols) in Southern Transitional Zone of Karnataka. Being a rainfed environment, the crop often experiences lower and unsustainable production due to erratic and unpredictable rainfall, cyclic droughts coupled with inherently poor soil fertility and undulating topography. Since leaf is the essential economic part with commercial value in tobacco, the number of leaves per plant, leaf area and net leaf dry matter production per unit area are the deciding factors in realizing higher productivity.

While severe drought can substantially decrease the number of leaves per plant, thickness and expansion of individual leaf; high and continuous rains cause lower photosynthetic activity, associated with nutrient loss, resulting in poor uptake by crop leading to lower productivity with deterioration in quality as well. Weather pattern in Southern Transition Zone (Zone 7) of Karnataka state has a bimodal rainfall pattern and receives rainfall during both South West and North East monsoon periods of which South West monsoon rains are of significance for tobacco crop growth, productivity and quality. Grand growth period of flue-cured tobacco in this zone coincides during later part of June and July months. Due to a shift in weather behavior and climate change, occurrence of high intensity rainfall more often during the peak periods of April and May (planting season) and late drought during July/August (grand growth/early harvesting period) have become more common. In addition, the number of sun shine hours and temperature regimes during crop growth /maturity phase were also found to vary and highly fluctuating over the years because of the climate change. Nearly two thirds of the tobacco growing areas in KLS falling under dry and semi-dry regions have been experiencing drought/moisture stress severely affecting the sustainable productivity and quality.

Key words: High density planting, productivity, FCV Tobacco

Growing plants in crop communities introduces competition for light, nutrients, moisture and carbon dioxide. Plant density is a major factor influencing competition within a canopy. Yield–density relationship for crops depends not only on the actual plant density but also on spatial arrangement of plants. A linear relationship exists between the logarithm of yield per plant and crowding (Duncan, 1984).

With this background and scientific evidences, the present study was conducted, to ascertain comparative benefits of high density planting over the conventional planting method in dry and semi dry zones of FCV tobacco growing regions of KLS.

MATERIAL AND METHODS

Three sites representing high, medium and low rainfall microclimatic zones were selected for the study for conducting the experiment trails in three different locations of KLS. Field experiments and large scale location trails were conducted in dry and semi dry zone in periodically drought affected FCV tobacco growing areas in light soils of Karnataka during 2014 to 2018 crop seasons, At each site the treatments were arranged in factorial design replicated thrice with a plot dimension of 100 m^2. The treatments consisting of four densities (18,181, 22,222, 24,691 and 31,250 plants/ha) were adopted with spacing of 100 x 55 cm (Control), 90 x 50 cm, 90 x 45 cm and 80 x 40 cm respectively. The regular popular Kanchan was planted during the 1st Fortnight of May and all the other cultural practices were common to all the treatments. The data with respect to productivity, quality, grade out turn, and chemistry were recorded and analyzed treatment wise for their influence on the leaf productivity and sustainability.

Treatment details

Tr.	Crop geometry/ spacing	Population/ ha	% increase Over control
T_1	100 x 55cm	18,181	-
T_2	90 x 50 cm	22,222	+22%
T_3	90 x 45 cm	24,691	+36%
T_4	80 x 40 cm	31,250	+72%

RESULTS AND DISCUSSION

The two crop season experiments conducted during 2014-15 and 2015-16, revealed significant cured leaf yield differences with different plant densities, in low and medium rainfall zones of KLS. However in high rainfall zone, no significant differences were recorded with different plant densities. A progressive cured leaf yield enhancement to an extent of 11-14% was observed with higher plant densities from 18,181 to 31,250 plants/ha during 2014-15. In several field crops like corn, cotton, soybean and horticultural crops like mango, papaya, litchi, relatively higher plant population have consistently produced higher productivity especially in dry land situations, low fertile and marginal soils, as the early ground coverage with higher LAI was achieved in shorter time. This early ground coverage will be of immense help to avoid soil moisture evaporation and the direct impact of rain drops on the soil surface especially in red loamy soils during the early phase of crop growth. High density plantation will also avoid excessive weed growth, which results in effective utilization of nutrients and moisture by

Table 1: Effect of plant densities treatments on cured leaf productivity Kg/ha

Plant density Plants/ha	Low rainfall zones		Medium rainfall zones		High rainfall zones	
	2014	2015	2014	2015	2014	2015
18,181	2681	1395	2020	1576	2418	2391
22,222	3059	1542	2273	1752	2225	2297
24,691	2971	1572	2310	1764	2278	2306
31,250	3019	1614	2279	1704	2029	2084
C.D.5%	**255**	**78.9**	**200.4**	**74.5**	**NS**	**138**

the crop. Apart from this, high density planting can better intercept solar radiation compared to low density or wider spacing between plants. A similar productivity enhancement was also observed during 2015 as well where increase in plant density enhanced the productivity up to 16 %.(Table 1). Cotton yields in upland rainfed regions can be increased by higher plant population that optimize numbers of bolls per plant and boll weight, while lowering cost of cultivation. A system of high density planting (HDP) leading to more rapid canopy closure and decreased soil water evaporation, is becoming popular to address water scarcity challenges (Jagvir Sing et al., 2012). In many countries, narrow row plantings have been adopted for productivity improvement in field crops like cotton (Ali et al. 2010).

In both the years of the experiments, the bright grade out turn which is an index of quality, declined when plant density was increased to 31,250 plants/ha at narrow spacing of 80 x 40 cm (Table 2). Significant reduction in bright grade production at very high plant density indicated competition for moisture, sunlight and carbon dioxide resulting in poor quality leaf production with unripe style tobacco. Flue cured tobacco varieties L-1158 and V- 3189, recorded higher bright grade and grade index with wider spacing (70 x 70 cm) compared to close (70 x 50 cm) spacing (Harishu Kumar et al., 2006). In the present study, the bright grade production was significantly higher at 90 x 50 or 90 x 45 cm spacing compared 80 x 40 cm (very closer) or 100 x 55 cm (normal) spacing in the low rainfall zones indicating the optimum density of around 22,222 to 24,691 population/ha in dry, low rainfall regions of Karnataka.

In contrast to dry zones, increase in plant population from 18,181 plants/ha progressively to 31,250 / ha resulted in a progressive productivity decline from 8 to16% in 2014 season and to an extent of 4-13% in 2015 in high rainfall zones. Similarly the bright grade leaf production dropped from 36% to 25% in 2014 and from 52% to 40% in 2015. This clearly indicated that high density plantings benefitted to a larger extent in dry and semi dry environments rather than wet zones / assured rainfall situations

The cured leaf quality parameters were not altered by the increased planting densities or crop geometry followed. Slightly lower leaf nicotine values were observed with higher population levels but the values were in the normal acceptable range (Table 3)

Table 2: Effect of plant densities treatments on bright grade leaf productivity (Kg/ha)

Plant density Plants/ha	Low rainfall zones		Medium rainfall zones		High rainfall zones	
	2014	2015	2014	2015	2014	2015
18,181	974	641	860	705	882	1234
22,222	1047	702	913	783	887	1112
24,691	1020	674	916	822	889	1071
31,250	795	505	698	617	513	838
C.D.5%	**178**	**61**	**NS**	**NS**	**228**	**213**

Table 3: Influence of plant densities on cured leaf quality parameters (mean values)

Plant density Plants/ha	Low rainfall region		Medium rainfall region		High rainfall region		Mean (Across the zones)	
	Nicotine	Sugars	Nicotine	Sugars	Nicotine	Sugars	Nicotine	Sugars
18,181	1.42	15.8	1.57	19.0	1.47	19.2	1.48	17.8
22,222	1.40	15.4	1.61	19.4	1.49	19.0	1.50	17.9
24,691	1.46	14.8	1.56	18.2	1.42	19.3	1.49	17.4
31,250	1.43	15.5	1.54	18.6	1.47	19.2	1.48	17.7

Table 4: Mean cured and bright grade leaf yield (Kg /ha) as influenced by higher density of planting in different crop seasons of dry and semi dry zones (field locations trails)

Treatments	Cured leaf yield (kg/ha) 2015-16		2016-17		2017-18		2018-19	
	Dry	Semi dry	Dry	Semi dry	Dry	Semi dry	Dry	Semi dry
100 x 55 cm	1667	1820	2433	2439	1863	-	1858	1949
90 x 50 cm	1832 (9.9%)	1989 (9.3%)	2754 (13.2%)	2815 (15.4%)	2031 (9.0%)	-	2139 (15.1%)	2202 (13.0%)

* Figures in the parenthesis indicate the percent increase over the control.

Treatments	Bright grade leaf yield (kg/ha) 2015-16		2016-17		2017-18		2018-19	
	Dry	Semi dry	Dry	Semi dry	Dry	Semi dry	Dry	Semi dry
100 x 55 cm	682	783	1361	1157	891	-	1164	1280
90 x 50 cm	692	922	1400	1284	944	-	1205	1284

Table 5: Mean cured leaf quality as influenced by high density planting dry/semi dry zones

Dry Zones

Spacingcm	X position			L position		
	Nicotine	Sugars	Chlorides	Nicotine	Sugars	Chlorides
100x55 cm	1.95	16.43	0.30	2.26	15.6	0.32
90x50 cm	1.89	16.51	0.28	2.25	15.3	0.34

Semi Dry zones

Spacingcm	X position (%)			L position (%)		
	Nicotine	Sugars	Chlorides	Nicotine	Sugars	Chlorides
100x55 cm	1.36	20.75	0.23	1.68	19.96	0.22
90 x50 cm	1.28	21.94	0.26	1.67	20.01	0.26

Further the mean data of the four seasons (2015-2019) large scale bulk trails conducted across the various dry and semi dry zone field locations in KLS revealed that the overall cured leaf productivity could be enhanced to an extent of 11.9-12.4% by increasing the plant density to 22,222 plants/ha at 90 x 50 cm from the recommended population of 18,181 plants/ha with 100 x 55 cm (Table 4). Similar trends were noticed in overall percent bright grade leaf production also. Early canopy coverage with higher Leaf Area Index (LAI) due to higher plant density than recommended plant population (18,181 plants/ha) reduced the evaporation losses from bare soil which also incidentally avoid the impact of rain drops on the soil resulting in enhanced crop survival during moisture stress and hot weather conditions prevailed during the crop growing periods. Advantage of narrow or ultra narrow row production system lies in more rapid canopy closure (Jost and Corthen, 2001) that in turn reduces weed competition (Snipes, 1996 and Wright *et al.*, 2004) and water evaporation (Krieg, 1996).There was no perceptual changes in the cured leaf quality characteristics and nicotine, sugars and chlorides values of the leaf were in normal desired range (Table 5).

In view of the encouraging and positive results obtained in both the experimental trails and the large scale field locations bulk trails in all the crop seasons, high density planting with reduced inter and intra row spacing by following crop geometry of 90 x 50 cm or 90 x 45 cm from the currently recommended spacing of 100 x 55 cm may be recommended as a one of the drought mitigation and climate resilient practice to optimize and stabilize the cured leaf productivity especially in periodically drought affected, low rainfall and poor fertility dry and semi dry FCV tobacco growing zones of KLS .

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