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Optimization of fertilizer doses and plant population in summer irrigated groundnut (*Arachis hypogaea*)

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Abstract
To stabilize the productivity of summer groundnut (*Arachis hypogaea)*, optimization of plant spacing and fertilizer levels is imperative. A field experiment was conducted at Coconut Research Station, Aliyarnagar during 2013-14 with three plant populations (P_1 - 30 x 10 cm, P_2 - 25 x 10 cm and P_3 - 20 x 10 cm) and graded nutrient levels (F_1- 75 %, F_2 - 100 % and F_3 -125 % RDN) in TMV 13 groundnut variety to bring out the effect of plant geometry and fertilizer levels on the system productivity and economic returns, in split plot design with each of the above treatments replicated thrice. Of the different spacings adopted, P_1 - plant population @ 3.33 lakhs per ha (30 x 10) cm recorded significantly higher kernel yield (2332 kg ha^{-1}) followed by P_2 - plant population @ 4.0 lakhs per ha (25 x 10) cm) whilst dry haulm yield although higher in P_1 (2935 kg ha^{-1}) did not attain statistical significance. The dry pod yield (2787 kg ha^{-1}), net returns (Rs. 68696 ha^{-1}) and benefit cost ratio (2.36) were higher in P_1 followed by P_2. As a natural corollary, plant stand was higher in P_3 with a plant population of 5.0 lakhs per ha (20 x 10 cm) followed by P_2. The number of branches, total number of pods per plant and harvest index were statistically superior with wider spacing (P_1) compared to the other spacings adopted. The percentage of sound matured kernels was higher in P_2 followed by P_1. Other parameters *viz.*, plant height, shelling out–turn remained unaltered with respect to the different spacings adopted. Application of 100 % RDN (F_2) was significantly superior over rest of the treatments (F_1 and F_3) with regard to kernel yield. F_2 and F_3 showed statistical superiority and parlance in majority of growth parameters, yield attributes and economics. Plant population of 3.33 lakhs per ha (30 x 10) cm along with application of 100 %RDN (25 – 50 – 75 NPK kg ha^{-1}) proved its superiority in kernel yield and economic returns.

Keywords: Plant population, summer irrigated groundnut, *Arachis hypogaea*

Introduction

Groundnut (*Arachis hypogaea* L.), the premier leguminous oilseed crop is widely cultivated in the tropics and sub tropics between 40°N and 40°S latitudes. Globally, India ranks first in groundnut acreage with an area of 7.0 m ha contributing 8.0 - 8.5 mt and stands second in production. In Tamil Nadu, area under groundnut is 3.38 lakh ha with a total production of 7.83 lakh tonnes. Groundnut is an energy rice crop but grown under energy starved conditions on marginal lands. Although groundnut is cultivated in one or more (*kharif, rabi* and summer) seasons, nearly 80% of acreage and production comes from *kharif* crop (June-October), and that from summer irrigated groundnut accounts for 16 % of the area and 28 % of the production. Cultivation of summer groundnut is undertaken mainly in the states of Tamil Nadu, Andhra Pradesh, Karnataka, Maharashtra, Gujarat and Orissa, with 9-12 irrigations per crop season. Summer groundnut reserves its advantages as less infestation to pests and diseases and better weed control compared to *kharif* groundnut. However, the average productivity of groundnut in India is 1300 kg/ha which is very less as compared to USA and China because the crop is mainly grown under low fertility and low input management, often subject to the vagaries of weather conditions (Sagvekar *et al*., 2015) [9]. In India, the productivity remains low due to an array of factors *viz.*, biotic and abiotic stresses, low or no use of plant nutrients, imbalanced fertilization, deficiencies of micronutrients etc. Judicious use of fertilizers is imperative for increasing agricultural production and reducing environmental pollution (Sarkar *et al*., 1997) [10]. Groundnut farmers use very less fertilizer resulting in severe mineral nutrient deficiencies due to inadequate and imbalanced use of nutrients (Veeramani & Subrahmaniyan, 2011) [12]. Sub optimal use of fertilizers is one of the major factors responsible for poor yield in groundnut. Nutritional disorders in groundnut account for an yield reduction of 30 – 50 percent. Appropriate and balanced nutrient management can only help to alleviate the production constraints existing in groundnut production.

Yield is a function of plant density and there is ample scope for increasing the yield by adjusting the plant density to an optimum level (Chaniyara *et al*., 2001) [2]. Planting density not only determines competition for light and nutrients, but also controls the distribution of dried materials between the organs and ultimately increases pod yield (Giayetto *et al*., 2003; Zheng *et al*., 2007; Rasekh *et al*., 2009; Song *et al*., 2011; Chen *et al*., 2013) [5, 15, 8, 11, 3]. Sub optimal plant stand in groundnut has been identified as one of the major constraints to realize full production potential. Hence, optimum plant population is required for better utilization of natural resources like light, moisture and nutrients, which consequently declines the risk of yield reduction and ensures higher productivity and returns per unit area. Hence it is imperative to study the impact of plant geometry and nutrient management on the productivity of summer irrigated groundnut.

Material and Methods

An experiment was conducted at Coconut Research Station, Aliyarnagar to explore options towards maximization of productivity of summer groundnut through optimization of spacing and fertilizer dosage. Experiment was conducted in split plot design with each of the following treatments replicated thrice across a plot size of 5 x 4 m^2. Test variety was TMV 13 and sowing was done in the third weeks of January 2013-15 to evade the deleterious effects of low temperature in early January. The soil is sandy loam in texture with pH – 7.26, electrical conductivity – 0.51 dSm^{-1}, organic carbon – 0.26 %, $KMnO_4$ N- 221 kg /ha, Olsen P – 18.75 kg/ha and $1NNH_4OAc$-K – 268 kg/ha. Recommended dose of nutrients (RDN) is 25 kg N, 50 kg P_2O_5 and 75 kg K_2O ha^{-1} applied as urea, single super phosphate and muriate of potash.

Treatment Details

A. Main plots (Plant Geometry)

P_1 – Plant population @ 3.33 lakhs per ha (30 x 10) cm
P_2 – Plant population @ 4.0 lakhs per ha (25 x 10) cm
P_3 - Plant population @ 5.0 lakhs per ha (20 x 10) cm

B. Sub- plots (Nutrient Management)

F_1 – 75 % Recommended dose of nutrients
F_2 - 100 % Recommended dose of nutrients
F_3 - 125 % Recommended dose of nutrients

The crop was harvested manually after attaining the physiological maturity (104 days). Harvested nuts were dried to 12% moisture, and weighed. Shelling percentage was calculated by dividing seed weight by pod weight. Kernel yield was calculated as the multiple of pod yield and shelling percentage. Harvest Index was computed as the ratio of economic yield and biological yield. Data was analysed statistically employing Panse and Sukhatme, 1985 [6].

Results and Discussion

(i) Plant Establishment and Growth attributes

As a natural corollary, plant stand was higher with the spacing of 20 x 10 cm irrespective of the fertilizer levels adopted. Also the stand was better with enhanced fertilizer level of 125 % RDN but it showed statistical parlance with 100 % RDN. Thus enhancing the nutrient level by 25 % did not register its positive impact on the plant stand. Of the interaction effects, plant stand was higher in P_3 x F_3 followed by P_3 x F_2. Although numerical ups and downs were recorded pertinent to plant height, still the differential nutrient levels, plant geometry and their interaction effects remained statistically on par. The results are in contrary to Gadade *et al*., (2018) [4] who observed maximum plant height with closer spacing and attributed the cause to the plant's necessity to grow more in upward direction for the fulfillment of light requirement for photosynthesis. Number of branches per plant ranged from 4.00 to 8.00 however it showed statistically parlance among various fertilizer levels and its interaction with plant geometry. Similar results were reported by Ramesh and Sabale, 2011. However the branches were statistically higher with the plant population of 3.33 lakhs per ha, which may be due to the optimum resource flow in the plant system with the spacing of 30 x 10 cm (Table 1).

(ii) Yield attributes and Yield

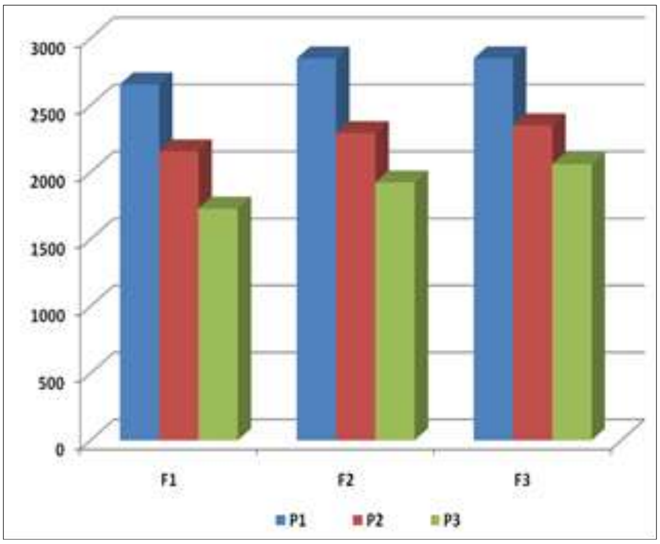
Number of pods per plant were higher with the plant density of 3.33 lakh plants per ha and 100 % RDN, which showed statistical parlance with 125 % RDN. This may be due to the early pod setting with optimum plant population compared to high density population. The results are in close proximity with that of Zhao *et al*., 2017 [17] who observed similar results in their experiment at Qingdao Agricultural University, Qingdao, Shandong, China. Interaction of P_1 x F_2 registered highest number of pods of 28.0 per plant and the lowest was registered in P_3 x F_1 (20.6 pods per plant). Dry pod yield was significantly higher with the plant spacing of 30 x 10 cm (Fig. 1), and statistical parlance was observed with respect to fertilizer levels although numerically higher value was registered with 125 % RDN. Attarde *et al*. (1998) [1], in his experiment conducted at Oilseeds Research Station, Jalgaon reported that row spacing of 30 cm to record significantly higher pod yield than 45 cm spacing. Kernel yield was higher with the plant spacing of 30 x 10 cm and was the lowest with the higher plant population. Fertilizer application of 100 % RDN paved way for the highest mean kernel yield of 2861 kg ha^{-1} and the lowest was recorded due to withholding 25 % of the recommended dose of nutrients. Interaction of P_1 and F_2 registered significantly higher kernel yield compared to the other combinations. Zheng *et al*. (2012) [16] and Zhao *et al*. (2013) [14] concluded that optimum plant density provided an increased crop growth and development because of extended leaf area which can avoid light leakage from canopy to soil surface, which would have contributed for increased kernel yield in P_1 (Table 2).

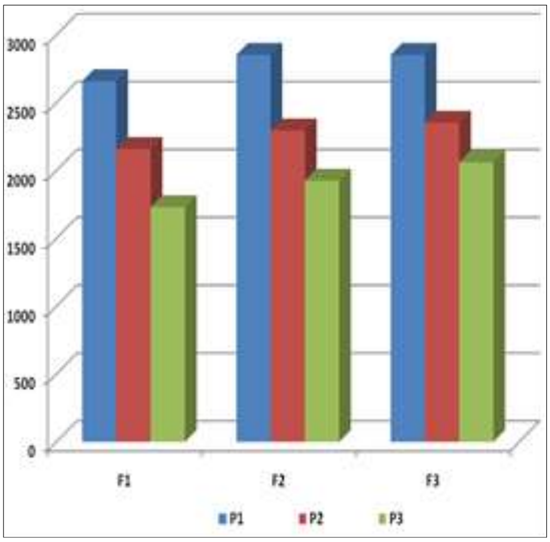
(iii) Harvest Index, Shelling out turn and Sound matured kernels

Dry haulm yield was numerically higher with the spacing of 30 x 10 cm and was statistically superior with the application of 100 % RDN (Fig. 1). Interaction effects of plant geometry and fertilization were statistically on par among themelves, although the interaction of P_1 x F_2 registered the highest dry haulm yield of 3083 kg ha^{-1}. Harvest index was statistically superior with P_1 and was the lowest in P_3. Statistical parlance was observed with respect to the different fertilizer levels and the interaction effects of plant geometry and fertilizer levels. An average harvest index was 0.44 was witnessed across the experiment. The shelling out turn was maximum in F_3 (71.1 %) followed by F_2 (70.8 %) and it was statistically superior over F_1. Differential plant geometry failed to register its superiority and the same trend replicated for the interaction effects also. The percentage of sound matured kernels was higher in F_2 (100 % NPK) followed by F_3 and it was statistically superior over F_1. Of the differential plant geometry, adoption of a spacing of 30 x 10 cm resulted in the highest percentage of sound matured kernels compared to the other plant densities. Of the interaction effects, P_1 x F_2 registered highest percentage of sound matured kernels compared to the other effects (Table 3).

(iv) Economics of Cultivation

The cost of cultivation was higher in P_3 due to the increased seed rate and higher plant population and the associated input requirement for the higher population. Of the fertilizer levels, higher cost of cultivation was incurred for 125 % RDN compared to other levels. Net returns was higher in F_2 and was the lowest in F_1. Plant geometry of 30 x 10 cm resulted in the highest net returns followed by the spacing levels of 25 x 10 and 20 x 10 cm. B:C ratio was higher with F_2 and F_3 and was the lowest in F_1. Plant spacing of 30 x 10 cm helped in accruing highest B:C ratio compared to the other levels. Interaction of P_1x F_2 registered the highest B:C ration of 2.39 compared to the other effects (Table 4).





Conclusions

In the present study, for groundnut, of the different spacing options attempted *viz.*, 30 x 10 cm, 25 x 10 cm, 20 x 10 cm, with varied fertilizer levels (75 %, 100 % and 125 % RDN), number of branches per plant, pod yield, dry haulm yield, kernel yield, percentage of sound matured kernels, shelling out turn and benefit cost ratio were higher in P1 (Spacing of 30 x 10 cm with a plant population of 3.33 lakhs per ha) and 100 % RDN (25 – 50 – 75 NPK kg ha^{-1}) due to the optimal utilization of natural and applied resources in the system.

Table 1: Plant stand and growth attributes of groundnut at harvest as influenced by fertilizer doses and plant population

Factors	Plant stand ('000 ha^{-1})				Plant height (cm)				Number of branches per plant			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
P_1	218.3	225.3	231.7	225.1	40.0	44.0	44.0	37.9	7.00	8.00	7.33	7.44
P_2	232.3	238.6	230.7	233.8	37.6	43.0	42.0	41.6	4.33	4.67	4.67	4.56
P_3	278.0	338.0	343.3	319.7	36.0	37.7	36.0	40.7	5.00	4.67	4.00	4.56
Mean	242.9	267.3	268.6	259.6	42.7	40.9	36.6	40.0	5.44	5.78	5.33	5.52
Mean comparison	S.Em ±		LSD (0.05)		S.Em ±		LSD (0.05)		S.Em ±		LSD (0.05)	
Main Plot (P)	7.86		21.8		3.03		NS		0.4800		1.333	
Sub Plot (F)	7.68		16.7		2.05		NS		0.4006		NS	
P at same level of F	13.4		31.9		4.20		NS		0.7426		NS	
F at same level of P	13.3		28.9		3.55		NS		0.6939		NS	

Table 2: Yield attributes of groundnut as influenced by fertilizer doses and plant population

Factors	Pods per plant				Dry pod yield (kg ha^{-1})				Kernel yield (kg ha^{-1})			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
P_1	23.0	28.0	27.4	26.2	2658	2852	2852	2787	1841	3150	2005	2332
P_2	21.9	23.5	23.5	22.9	2158	2294	2352	2268	1466	2970	1671	2036
P_3	20.6	21.7	22.2	21.9	1730	1925	2061	1906	1126	2464	2258	1949
Mean	21.8	24.4	24.4	23.5	2182	2357	2422	2321	1478	2861	1978	2106
Mean comparison	S.Em ±		LSD (0.05)		S.Em ±		LSD (0.05)		S.Em ±		LSD (0.05)	
MAIN PLOT (P)	0.1928		0.5358		150.2		417		74.8		208	
SUB PLOT (F)	0.2146		0.4678		165.8		NS		97.7		213	
P at same level of F	0.3597		0.8457		278.5		NS		157		363.6	
F at same level of P	0.3712		0.8102		287.2		NS		169		368.7	

Table 3: Harvest Index, Shelling out turn and Sound matured kernels of groundnut as influenced by fertilizer doses and plant population

Factors	Dry Haulm yield (kg ha^{-1})				Harvest Index				Shelling out turn (%)				Sound Matured Kernels (%)			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
P_1	2720	3083	2994	2935	0.49	0.48	0.48	0.48	69.8	73.0	71.3	71.4	87.6	97.1	93.8	92.8
P_2	2574	2883	2956	2805	0.45	0.44	0.43	0.44	68.8	70.6	71.7	70.4	92.8	94.8	94.7	94.1
P_3	2623	2769	2737	2710	0.39	0.40	0.42	0.41	66.2	68.6	70.3	70.8	88.1	91.9	91.9	90.6
Mean	2639	2912	2896	2816	0.44	0.44	0.45	0.44	68.3	70.8	71.1	70.0	89.5	94.6	93.4	92.5
Mean comparison	S.Em ±		LSD (0.05)		S.Em ±		LSD (0.05)		S.Em ±		LSD (0.05)		S.Em ±		LSD (0.05)	
MAIN PLOT (P)	67.6		NS		0.02010		0.0558		2.411		NS		0.6984		1.94	
SUB PLOT (F)	70.3		153		0.01942		NS		0.895		1.95		0.8248		1.79	
P at same level of F	120.2		NS		0.03403		NS		2.723		NS		1.3595		3.17	
F at same level of P	121.7		NS		0.03363		NS		1.551		NS		1.4286		3.11	

Table 4: Economics of cultivation of groundnut with differential plant geometry and fertilizer levels

Factors	Cost of Cultivation (Rs. ha^{-1})				Net Returns (Rs. ha^{-1})				B:C			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
P_1	47968	47295	48371	47878	65786	70817	69485	68696	2.36	2.39	2.33	2.36
P_2	48983	48492	49568	49014	44028	47641	49034	46901	1.88	1.89	1.90	1.89
P_3	49471	53358	56430	53086	26591	33511	37177	32426	1.52	1.66	1.71	1.63
Mean	48807	49715	51456	49993	45468	50656	51899	49341	1.92	1.98	1.98	1.96

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