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Standardization of planting dates, spacings and different nutrition levels in potato tuber yield

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Abstract

Field experiment carried out during the two successive growth seasons of 2018-19 and 2019-20 (*Rabi*) at College farm, College of Horticulture, Venkataramannagudem, West Godavari District of Andhra Pradesh. There were 18 treatment combinations consisting of 3 factors viz., planting dates (3 levels viz., D₁: October 15th, D₂: November 1st and D₃: November 16th), plant spacings (2 levels viz., S₁: 60 cm x 20 cm, S₂: 75 cm x 20 cm) with NPK doses (3 levels viz., F₁: 120:60:150 kg ha⁻¹, F₂: 160:80:200 kg ha⁻¹ and F₃: 200:100:250 kg ha⁻¹). Potato variety Kufri Surya was used in this experiment and the treatments were laid in a factorial randomized block design (FRBD) replicated thrice under open field conditions. As per pooled results, November 1st planting (D₂) recorded maximum values for number of tubers plant⁻¹, average tuber weight, yield plant⁻¹, yield plot⁻¹, marketable tuber yield, total tuber yield, harvest index and minimum unmarketable tuber yield. These similar trends were also observed with application of NPK @ 160:80:200 kg ha⁻¹ (F₂) for all the yield characters. Among spacings, 60 × 20 cm spacing (S₁) recorded the maximum number of tubers plant⁻¹, yield plot⁻¹, marketable tuber yield and total tuber yield whereas 75 × 20 cm spacing (S₂) noticed the higher values for average tuber weight, yield plant⁻¹, harvest index and lowest unmarketable tuber yield. Among three-way interactions, D₂ S₂ F₂ combination (November 1st planting + spacing of 75 × 20 cm + NPK applied @ 160:80:200 kg ha⁻¹) significantly recorded average tuber weight, yield plant⁻¹ and harvest index whereas D₂ S₁ F₂ combination (November 1st planting + 60 × 20 cm spacing + NPK @ 160:80:200 kg ha⁻¹) gave maximum number of tubers plant⁻¹, yield plot⁻¹, marketable tuber yield and total tuber yield. Three-way interactions found non-significant effect on unmarketable tuber yield.

Keywords: Average tuber weight, No. of tubers, marketable tuber yield, total tuber yield and harvest index

Introduction

Potato (*Solanum tuberosum* L.) is a high value marketable crop that has wide adaptability with higher return and food production, provides a source for low-cost nutrition and energy per unit area and time. The area and production under potato have increased rapidly in Asia against a declining trend in western countries. In India, potato is cultivated in an area of 2.15 lakh ha with an annual production of 485.29 lakh tonnes and productivity of 20.55 tha⁻¹ (FAO, 2018). A potato tuber contains 80% water and 20% dry matter consisting of carbohydrates (22.6 g), which are essential for energy (97 kcal), 14% starch, 2% protein, 2% sugars, 1% minerals like potassium, phosphorous, magnesium, iron, 0.6% fibre, 0.1% fat and vitamins like thiamin, riboflavin, niacin, pyridoxine and ascorbic acid per 100 g fresh weight (Gopalan *et al.*, 1972) [8]. Potato planting

time for each region is one of the factors that have a significant role in the performance of this product. Each stage of growth coincide with environmental conditions is desired. Delayed planting dates cause yield and quality reduction (Ahmed *et al.*, 2017) [1]. The optimization of plant density is one of the most important subjects of potato production management, because it affects seed cost, plant development, yield and quality of the crop (Bussan *et al.*, 2007) [5]. Plant spacing also influences potato yield and growth, since it determines plant density. In general, closer spacing to certain extent will increase the yield of potato tubers. Under the wider spacing, the plants were more vigorous in terms of leaf size, which might be due to less competition for light, nutrients and moisture (Rai *et al.*, 2003) [10]. Low NPK fertilization leads to reduction in growth and yield in potato and also plants show nutrient

deficiency symptoms. The balanced fertilizer application increased yield per unit area (Al-Moshileh and Errebi, 2004) [2]. Nitrogen is essential for better plant growth and more dry matter production (Roy and Jaiswal, 1998) [9], whereas phosphorus fertilization contributes to early development, tuberization and enhances tuber maturation. Potassium influences both yield and tuber quality and also enhances plant resistance. The present experiment was carried out with potato variety Kufri Surya to standardize the different planting dates, spacings and NPK nutrition levels on yield of potato under coastal region of Andhra Pradesh.

Materials and Methods

This field experiment was conducted at College of Horticulture, VR Gudem, Dr. YSR Horticultural University, West Godavari District of Andhra Pradesh during winter season of 2018-19 and 2019-20 on "Standardization of planting dates, spacings and different nutrition levels in Potato tuber yield". There are 18 treatment combinations consisting of three factors viz., planting dates (3 levels viz., D₁: October 15th, D₂: November 1st and November 16th), plant spacings (2 levels viz., S₁: 60 cm x 20 cm, S₂: 75 cm x 20 cm) with F₁: 120:60:150 kg ha⁻¹, F₂: 160:80:200 kg ha⁻¹ and F₃: 200:100:250 kg ha⁻¹). The treatments were laid in a factorial randomized block design (FRBD) replicated thrice under open field conditions with Kufri Surya variety. FYM @ 25 and full dose of SSP, 1/3rd dose of urea and MOP were applied in the last ploughing as basal dose. The remaining dose of Urea and MOP were applied in two equal split doses, first dose at 30 DAP and final dose at 50 DAP.

The following yield parameters were recorded during the course of study viz., No. of tubers plant⁻¹, average tuber weight, yield plant⁻¹, yield plot⁻¹, marketable yield ha⁻¹, unmarketable tuber yield ha⁻¹, total tuber yield ha⁻¹ and harvest index.

Results and Discussion

Number of tubers plant⁻¹ and average tuber weight (g)

The interaction effect was non-significant in all two way combinations but was found significant in three-way combination of planting dates (D) x spacing (S) x NPK level (F) for Number of tubers plant⁻¹ and interaction effects between D x S, S x F and D x S x F differed significantly with each other but D x F did not differ significantly with respect to average tuber weight. According to pooled analysis, maximum number of tubers plant⁻¹ (6.20) and average tuber weight (85.68 g) were recorded from November 1st (D₂) planting. The least number of tubers plant⁻¹ (4.67) and average tuber weight (64.78 g) was recorded in October 16th planting (D₁). Regarding two plant spacings, 60 x 20 cm spacing (S₁) resulted in higher number of tubers plant⁻¹ (5.76) and lowest average tuber weight (71.85g) whereas 75 x 20 cm spacing (S₂) recorded the highest average tuber weight (79.97g) and least number of tubers plant⁻¹ (5.21) in potato. Among the fertilizer levels, the mean number of tubers plant⁻¹ ranged from a maximum of 5.82 and maximum average tuber weight (80.31g) with the application of NPK @ 160:80:200 kg ha⁻¹(F₂) to a minimum of 5.10 and 70.70 g due to application of NPK @ 120:60:150 kg ha⁻¹ (F₁).

Table 1: Number of tubers plant⁻¹ and average tuber weight as influenced by planting dates, spacing and NPK levels during 2018-19, 2019-20 and pooled date of potato

Spacing (S)	NPK levels (F)	Planting dates (D)							
		Number of tubers plant ⁻¹				Average tuber weight (g)			
	NPK kg ha ⁻¹	D ₁	D ₂	D ₃	Mean	D ₁	D ₂	D ₃	Mean
S ₁ (60 x 20 cm)	F ₁ (120:60:150)	4.58	6.04	5.25	5.29	58.50	74.19	70.13	67.61
	F ₂ (160:80:200)	5.09	6.96	6.38	6.14	67.27	81.21	77.21	75.23
	F ₃ (200:100:250)	4.96	6.30	6.27	5.84	64.21	77.55	76.42	72.73
	Mean	4.88	6.43	5.97	5.76	63.33	77.65	74.59	71.85
S ₂ (75 x 20 cm)	F ₁ (120:60:150)	4.34	5.46	4.92	4.91	60.46	88.17	72.73	73.79
	F ₂ (160:80:200)	4.59	6.42	5.51	5.50	69.81	100.00	86.38	85.40
	F ₃ (200:100:250)	4.46	6.04	5.12	5.21	68.42	92.94	80.80	80.72
	Mean	4.46	5.97	5.18	5.21	66.23	93.70	79.97	79.97
For Comparing planting dates (D) and fertilizer levels (F)									
F ₁ (NPK @ 120:60:150 kg ha ⁻¹)		4.46	5.75	5.09	5.10	59.48	81.18	71.43	70.70
F ₂ (NPK @ 160:80:200 kg ha ⁻¹)		4.84	6.69	5.94	5.82	68.54	90.61	81.79	80.31
F ₃ (NPK @ 200:100:250 kg ha ⁻¹)		4.71	6.17	5.70	5.52	66.32	85.24	78.61	76.72
Mean		4.67	6.20	5.58	5.48	64.78	85.68	77.28	75.91
Factor		S Em+ CD at 5%				S Em+ CD at 5%			
Planting dates (D)		0.10		0.29		0.47		1.35	
Spacing (S)		0.08		0.24		0.38		1.10	
Fertilizer levels (F)		0.10		0.29		0.47		1.35	
D x S		0.14		NS		0.66		1.91	
D x F		0.18		NS		0.81		NS	
S x F		0.14		NS		0.66		1.91	
D x S x F		0.25		0.71		1.15		3.30	

Planting dates (D): D₁ - October 15th, D₂ - November 1st, D₃ - November 16th;

NS: Non-significant; DAP: Days after planting

According to three-way interaction effects, the treatment combination of D₂ S₁ F₂ (November 1st planting + spacing 60 x 20 cm + NPK @160:80:200 kg ha⁻¹) recorded the highest number of tubers plant⁻¹ (6.96) while, the lowest number of tubers per plant (4.34) was recorded in D₁ S₂ F₁

(October 16th planting + 75 x 20 cm spacing + NPK @ 120:60:150 kg ha⁻¹). Among two way interactions, maximum average tuber weight (93.70 g) was noticed on D₂ S₂ followed by D₃ S₂ (79.77 g) and it was minimum (63.33 g) in D₁ S₁.

Under S x F interaction, average tuber weight was maximum (85.40 g) in 75 x 20 cm spacing with NPK applied @ 160:80:200 kg ha⁻¹ (S₂ F₂) whereas the lowest (67.61 g) in 60 x 20 cm spacing with NPK applied @ 120:60:150 kg ha⁻¹ (S₁ F₁). With regarding to three-way interaction, D₂ S₂ F₂ treatment combination registered the maximum average tuber weight (100.0 g) followed by D₂ S₂ F₃ (92.94 g) whereas D₁ S₁ F₁ treatment attained the minimum average tuber weight (58.50 g).

Total number of tubers plant⁻¹ increased at narrow plant spacing (60 x 20 cm) and decreased at wider plant spacing (75 x 20 cm). This might be due to efficient utilization of available nutrients among the plants at narrow plant spacing which leads to linearly increasing tuber numbers per plant as reported by Arega *et al.* (2018) [3] in potato.

Among NPK levels, number of tubers per plant was at the highest in 160:80:200 NPK kg ha⁻¹ (F₂) treatments which were superior to the rest of the treatments. The increment of tuber number per plant with increased fertilizer level up to a certain point *i.e.*, F₂ may be attributed to an increase in stolon number through its effect on gibberellin biosynthesis in the potato plant which was more favorable at this nutrient level as compared to the other levels. The results are in conformity with those reported by Banjare *et al.* (2014) [4],

and Vikas *et al.* (2017) [14] in potato.

Yield plant⁻¹ (g) and yield plot⁻¹

Two years pooled data presented in table 2 indicated that effect of planting dates, spacing, NPK levels and their interactions. Yield plant⁻¹ and Yield plot⁻¹ were significantly higher in November 1st (D₂) planting followed by November 16th (D₃) planting and the same was minimum with those planted on October 16th (D₁). Among the spacings, 75 x 20 cm recorded the highest yield plant⁻¹ and lowest yield plot⁻¹ whereas 60 x 20 cm recorded the highest yield plot⁻¹ and lowest yield plant⁻¹. The maximum and minimum yield plant⁻¹ and yield plot⁻¹ was recorded by the application of NPK @ 160:80:200 kg ha⁻¹ and NPK @ 120:60:150 kg ha⁻¹, respectively. As per two way interactions D x S, D x F were found significant and S x F was found non-significant for yield plant⁻¹ and no significant differences were observed for yield plot⁻¹ in potato in all two way treatment combinations D x S, D x F, S x F. Regarding three-way interaction means (D x S x F), yield plant⁻¹ was maximum under D₂ S₂ F₂ and minimum in D₁ S₁ F₁. Similarly, yield plot⁻¹ was higher in treatment combination of D₂ S₁ F₂ and lower in D₁ S₂ F₁.

Table 2: Yield plant⁻¹ and Yield plot⁻¹ as influenced by planting dates, spacing and NPK levels in potato (pooled)

Spacing (S)	NPK levels (F)	Planting dates (D)							
		Yield plant ⁻¹ (g)				Yield plot ⁻¹ (kg)			
	NPK kg ha ⁻¹	D ₁	D ₂	D ₃	Mean	D ₁	D ₂	D ₃	Mean
S ₁ (60 x 20 cm)	F ₁ (120:60:150)	144.21	212.10	202.92	186.41	8.74	10.96	9.60	9.77
	F ₂ (160:80:200)	158.70	241.13	220.18	206.67	11.41	14.05	12.40	12.62
	F ₃ (200:100:250)	157.27	219.93	214.89	197.36	9.83	12.68	11.00	11.17
	Mean	153.40	224.39	212.66	196.81	9.99	12.56	11.00	11.19
S ₂ (75 x 20 cm)	F ₁ (120:60:150)	157.65	247.47	213.58	206.23	7.87	10.32	8.65	8.95
	F ₂ (160:80:200)	172.34	280.34	233.08	228.58	10.76	13.04	11.57	11.79
	F ₃ (200:100:250)	169.39	261.95	222.99	218.11	9.19	11.49	10.16	10.28
	Mean	166.46	263.25	223.22	217.64	9.27	11.62	10.13	10.34
For Comparing planting dates (D) and fertilizer levels (F)									
F ₁ (NPK @ 120:60:150 kg ha ⁻¹)		150.93	229.79	208.25	196.32	8.31	10.64	9.13	9.36
F ₂ (NPK @ 160:80:200 kg ha ⁻¹)		165.52	260.73	226.63	217.63	11.08	13.55	11.99	12.20
F ₃ (NPK @ 200:100:250 kg ha ⁻¹)		163.33	240.94	218.94	207.74	9.51	12.08	10.58	10.72
Mean		159.93	243.82	217.94	207.23	9.63	12.09	10.56	10.76
Factor		S Em+ CD at 5%				S Em+ CD at 5%			
Planting dates (D)		1.14				0.13			
Spacing (S)		0.93				0.11			
Fertilizer levels (F)		1.14				0.13			
D x S		1.62				0.19			
D x F		1.98				0.23			
S x F		1.62				0.19			
D x S x F		2.80				0.32			

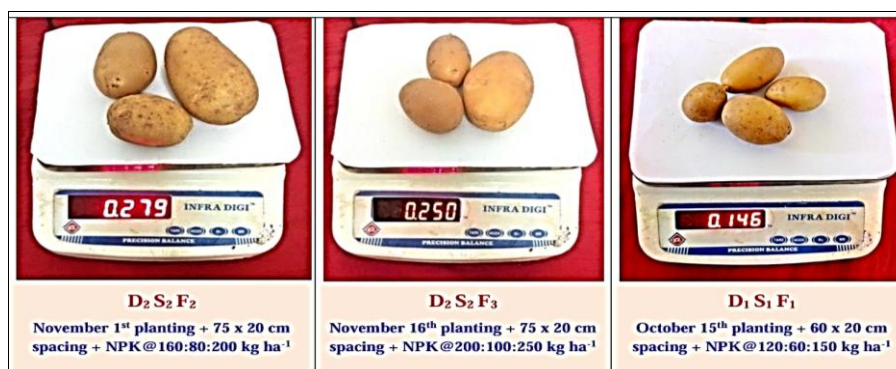


Fig 1: Yield plant⁻¹ (g) in different combinations of planting dates, spacing and NPK levels in potato

Higher per plant yield in wider spaced plants could be due to the more land area available per plant and widely spaced plants having less competition for nutrient uptake, water, light and air which helped the plant to get more nutrients, water, light and air resulting in increased yield parameters. This finding is in conformity with the result of Sunita *et al.* (2017a) ^[11] in sweet potato and Ganie *et al.* (2016) ^[7] in potato. Regarding yield plot⁻¹, 60 × 20 cm spacing recorded the superior yield plot⁻¹ as compared to 75 × 20 cm spacing. Though the individual tuber weight was less in closer spacing, per plot tuber yield was maximum due to more number of plants per unit area. Thus, 60 × 20 cm spaced plants were successful in full exploitation of space leading to efficient utilization of available resources. Similar results

were quoted by Ganie *et al.* (2016) ^[7] in potato and Thirupal *et al.* (2016) ^[13] in broccoli.

With regard to NPK levels, tuber weight per plant and tuber yield per plot were found to increase with increased levels of NPK up to the level of F₂ (160:80:200 kg ha⁻¹) which was found superior as compared to both higher and lower NPK levels (F₃ and F₁). The higher yield in F₂ could be attributed due to maximum plant height, number of haulms and number of leaves per plant and these were significantly associated to increased tuber yield on account of balanced supply of NPK along with other nutrient elements.

Marketable tubers yield (t ha⁻¹) and unmarketable tuber yield (t ha⁻¹)

Table 3: Marketable tubers yield and unmarketable tuber yield as influenced by planting dates, spacing and NPK levels in potato (pooled)

Spacing (S)	NPK levels (F)	Planting dates (D)							
		Marketable tuber yield (t ha ⁻¹)				Unmarketable tuber yield (t ha ⁻¹)			
		D ₁	D ₂	D ₃	Mean	D ₁	D ₂	D ₃	Mean
S ₁ (60 x 20 cm)	F ₁ (120:60:150)	12.23	16.01	14.03	14.09	2.58	1.95	2.01	2.18
	F ₂ (160:80:200)	15.20	19.70	17.95	17.62	1.91	1.63	1.74	1.76
	F ₃ (200:100:250)	13.76	17.46	16.17	15.80	2.12	1.91	1.91	1.98
	Mean	13.73	17.72	16.05	15.83	2.20	1.83	1.89	1.97
S ₂ (75 x 20 cm)	F ₁ (120:60:150)	11.73	15.15	13.42	13.43	1.98	1.55	1.61	1.71
	F ₂ (160:80:200)	14.76	18.21	17.07	16.68	1.48	1.35	1.42	1.42
	F ₃ (200:100:250)	13.02	16.35	15.35	14.91	1.79	1.46	1.46	1.57
	Mean	13.17	16.57	15.28	15.01	1.75	1.45	1.50	1.57
For Comparing planting dates (D) and fertilizer levels (F)									
F ₁ (NPK @ 120:60:150 kg ha ⁻¹)		11.98	15.58	13.72	13.76	2.28	1.75	1.81	1.95
F ₂ (NPK @ 160:80:200 kg ha ⁻¹)		14.98	18.95	17.51	17.15	1.70	1.49	1.58	1.59
F ₃ (NPK @ 200:100:250 kg ha ⁻¹)		13.39	16.91	15.76	15.35	1.96	1.69	1.69	1.78
Mean		13.45	17.15	15.66	15.42	1.98	1.64	1.69	1.77
Factor		S Em± CD at 5%				S Em± CD at 5%			
Planting dates (D)		0.12		0.36		0.06		0.17	
Spacing (S)		0.10		0.29		0.05		0.13	
Fertilizer levels (F)		0.12		0.36		0.06		0.17	
D x S		0.18		NS		0.08		NS	
D x F		0.22		NS		0.10		NS	
S x F		0.18		NS		0.08		NS	
D x S x F		0.30		0.87		0.14		NS	

Planting dates (D): D₁ - October 15th, D₂ - November 1st, D₃ - November 16th;

NS: Non-significant; DAP: Days after planting

The efficient synthesis and translocation of photosynthates to the tubers when adequate nutrients were supplied might be the reason for respective merit in dry matter and uptake of nutrients thus leading to greater tuber yields. Similar findings were also reported by Sten *et al.* (2017) ^[12] and Vikas *et al.* (2017) ^[14] in potato.

The maximum marketable tuber yield and unmarketable tuber yields were observed at a closer spacing of 60 × 20 cm whereas 75 × 20 cm wider spacing, recorded the minimum marketable tuber yield and unmarketable tuber yields in potato. Among NPK levels, application of NPK @ 160:80:200 kg ha⁻¹ (F₂) recorded the highest marketable tuber yield (17.15 ha⁻¹) with lowest unmarketable tuber yields was obtained. Similarly, NPK @ 120:60:150 kg/ha (F₁) registered the lowest marketable tuber yield and highest unmarketable tuber yields in potato. Two way interactions between D x S, D x F and S x F were found to possess non-significant differences but three-way interaction of D x S x F was significant with respect to marketable tuber yield and there is no significant difference between D x S x F

interactions for unmarketable tuber yield. D₂ S₁ F₂ combination resulted with maximum marketable tuber yield while, D₁ S₂ F₁ combination yielded minimum marketable tuber yield.

Total tuber yield and harvest index

The data (Table 4) on total tuber yield and harvest index as influenced by planting dates, spacing, NPK levels and their interaction revealed significant differences. The plants of November 1st (D₂) planting produced maximum total tuber yield (18.79 t ha⁻¹) and harvest index (65.52%) followed by November 16th (D₃) planting and minimum total tuber yield (15.42 t ha⁻¹) and harvest index (55.21%) were observed in October 15th planting (D₁). Among spacings, 60 × 20 cm (S₁) higher total tuber yield (17.80 t ha⁻¹) and lower harvest index (56.87%) were attained while, spacing of 75 × 20 cm (S₂) recorded the maximum harvest index (60.72%) and minimum total tuber yields (16.57 t ha⁻¹) in potato. NPK levels showed a distinctly significant influence on total yield of potato. Application of NPK at the rate of 160:80:200 kg

ha⁻¹(F₂) gave the highest total tuber yield (18.74 t ha⁻¹) and harvest index (61.97%) whereas NPK @ 120:60:150 kg ha⁻¹ (F₁) recorded the lowest values for total tuber yield (15.70 t ha⁻¹) and harvest index (55.53%). The interaction effect was non-significant in all two way combinations but was found significant in three-way combination of planting dates x

spacing x NPK level. Among the three-way interaction means, D₂ S₁ F₂ recorded the highest total tuber yield (21.33 t ha⁻¹) followed by D₃ S₁ F₂ (19.69 t ha⁻¹) whereas the least total yield (13.71 t ha⁻¹) was recorded under D₁ S₂ F₁. Harvest index (70.25%) was higher in D₂ S₂ F₂ and lower (49.54%) in D₁ S₁ F₁ treatment combinations.

Table 4: Total tuber yield and harvest index as influenced by planting dates, spacing and NPK levels in potato (pooled)

Spacing (S)	NPK levels (F)	Planting dates (D)							
		Total tuber yield (t ha ⁻¹)				Harvest index (%)			
		D ₁	D ₂	D ₃	Mean	D ₁	D ₂	D ₃	Mean
S ₁ (60 x 20 cm)	F ₁ (120:60:150)	14.80	17.96	16.03	16.26	49.54	57.24	54.77	53.85
	F ₂ (160:80:200)	17.11	21.33	19.69	19.38	55.79	64.35	59.36	59.83
	F ₃ (200:100:250)	15.88	19.37	18.07	17.77	53.56	60.18	56.99	56.91
	Mean	15.93	19.55	17.93	17.80	52.96	60.59	57.04	56.87
S ₂ (75 x 20 cm)	F ₁ (120:60:150)	13.71	16.70	15.03	15.14	55.10	60.34	56.20	57.22
	F ₂ (160:80:200)	16.24	19.56	18.48	18.09	60.04	70.25	62.02	64.10
	F ₃ (200:100:250)	14.81	17.81	16.81	16.48	57.22	65.97	59.36	60.85
	Mean	14.92	18.02	16.77	16.57	57.45	65.52	59.19	60.72
For Comparing planting dates (D) and fertilizer levels (F)									
F ₁ (NPK @ 120:60:150 kg ha ⁻¹)		14.25	17.33	15.53	15.70	52.32	58.79	55.49	55.53
F ₂ (NPK @ 160:80:200 kg ha ⁻¹)		16.68	20.44	19.09	18.74	57.91	67.30	60.69	61.97
F ₃ (NPK @ 200:100:250 kg ha ⁻¹)		15.34	18.59	17.44	17.12	55.39	63.08	58.17	58.88
Mean		15.42	18.79	17.35	17.19	55.21	63.06	58.12	58.79
Factor		S Em± CD at 5%				S Em± CD at 5%			
Planting dates (D)		0.12				0.58			
Spacing (S)		0.10				0.47			
Fertilizer levels (F)		0.12				0.58			
D x S		0.17				0.82			
D x F		0.21				1.00			
S x F		0.17				0.82			
D x S x F		0.30				1.42			

Planting dates (D): D₁ - October 15th, D₂ - November 1st, D₃ - November 16th;

NS: Non-significant; DAP: Days after planting

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