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Effect of nutrient management and plant geometry on different maturity group varieties of soybean

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Abstract

The field investigation entitled “effect of nutrient management and plant geometry on different maturity group varieties of soybean” was conducted at Regional Research Centre, Amravati under Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during *kharif* 2017-18 to 2019-20. The experiment was laid out in a split plot design (Main plot (A): Spacing, S₁: 45 x 05, S₂: 30x10 cm, (B) Varieties V₁: JS-9560 (Extra early 80-85 days, V₂: JS-9305 (Early 90-95 days) and V₃: JS-9752 (Medium 98-102 days), Sub plot: Nutrient Schedule N₁ 50% RDF, N₂: 75% RDF, N₃: 100% RDF (30:75:30 NPK/ha) N₄: 125% RDF) with three replications with a view to find out effect of nutrient management and plant geometry on different maturity group varieties of soybean and economics of the treatments. From, pooled data over the three years revealed that, spacing showed non significant effect. In varietal comparison, variety JS- 9752 (V₃) yielded significantly superior (1890 kg ha⁻¹) as compare to variety JS-9560 (1730 kg ha⁻¹) and JS-9305 (1792 kg ha⁻¹). In case of straw yield variety JS-9752 (2433 kg ha⁻¹) recorded significantly superior straw yield over JS-9560 (2165 kg ha⁻¹) and JS-9305 (2295 kg ha⁻¹). Variety JS-9752 showed significantly higher Gross monetary returns and B:C ratio as compare to other varieties but at par with variety JS-9305 in case of net monetary returns. Nutrient management treatment N₃ (100% RDF) recorded significantly higher seed yield i.e. 1976 kg ha⁻¹ over the treatment N₁ and N₂ but at par with N₄ (1903 kg ha⁻¹). Significantly highest straw yield was recorded in treatment 100% RDF (2615 kg ha⁻¹) as compare to treatments N₁, N₂ and N₃. Nutrient management treatment N₃ (100% RDF) showed significantly higher gross monetary return (65295 Rs ha⁻¹), net monetary return (35584 Rs ha⁻¹) and B:C ratio (2.19) as compare to rest of the nutrient management treatments but at par with treatment N₄ i.e. 125% RDF in case of GMR. Treatment combination of S₁xV₃ (spacing 45 X 05 cm with variety JS-9752) showed significantly higher seed yield (1984 kg ha⁻¹), straw yield (2554 kg ha⁻¹), GMR (65608 Rs ha⁻¹) and NMR (36825 Rs ha⁻¹) over rest of the treatment combinations. Variety JS-9752 and nutrient management 100% RDF recorded significantly highest seed yield (2081 kg ha⁻¹), straw yield (2746 kg ha⁻¹) GMR (68711Rs ha⁻¹) and NMR (38081Rs ha⁻¹) over all other treatment combinations but at par with treatment combinations V₂xN₃ and V₃xN₄. Treatment combination of V₃ x N₃ was at par with V₁ x N₃ in respect of NMR in pooled data. Treatment combination S₁- (45 x 05 cm) x V₃ (JS-9752) x N₃ (100% RDF (30:75:30 NPK/ha) recorded significantly highest seed yield (2174 kg ha⁻¹), straw yield (2891 kg ha⁻¹), GMR (71775 Rs ha⁻¹) and NMR (41146 Rs ha⁻¹) as compare to rest of all treatment combinations except treatment combination of S₁xV₃xN₄, S₂xV₃xN₃ and S₂xV₃xN₄ but treatment combination S₁xV₃xN₃ was also found at par with S₂xV₂xN₃, S₂xV₂xN₄ in respect of seed yield, S₂xV₂xN₃ in respect of GMR and S₁xV₂xN₃, S₂xV₂xN₃ in respect of NMR in pooled results respectively.

Keywords: Soybean, genotypes, plant geometry, maturity group

Introduction

Soybean (*Glycine max* (L.) Merr.) ranks first as an oilseed crop of the world. It has a remarkable value in agriculture as a good supply of high quality plant protein and vegetable oils. Soybean seed contains 40-45% protein, 20-26% carbohydrate, 20-22% oil and a high amount of Ca, P and vitamins (Rahman *et al.*, 2011)^[8].

Soybean has already emerged as one of the major *Kharif* crop of the Vidarbha region. Being a short duration legume crop it is an ideal for various intercropping as well as sequential cropping system.

Soybean is a very energy-rich grain legume containing 40% protein and 19% oil in the seeds. The crop is adapted to a wide range of climate conditions. The highest soybean yields are

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produced in near neutral soils but good yields can be obtained. Fertilizers play a key role in increasing agricultural production as the crop yields increased considerably by appropriate doses of fertilizers but application fertilizer of any nutrients by the farmer without information on soil fertility status and nutrient requirement by crop affect soil and crop adversely. For sustaining the production system, it is very essential that the nutrient demand of a crop to produce a definite yield and the amount removed from the soil should be perfectly matched. Nutrient recovery from applied fertilizers is primarily important and which varies according to crop species, management practices, soil properties and environmental conditions and above all nutrient sources. The poor or higher plant population is one of the limiting factors for higher soybean production in this region with new released varieties. Adjusting planting density is an important tool to optimize crop growth and time required for canopy closure in addition to achieve maximum biomass and grain yield. Selection of new varieties plays a vital role in crop production, particularly in new areas of introduction. Hence present study is undertaken to find out effect of nutrient management and plant geometry on different maturity group varieties of Soybean and to find out the economics of the treatments.

Materials and Methods

The experiment was laid during *Kharif* 2017-18 to 2019-20 in split plot design with Main Plot i.e. Factor A: Spacing (S1- 45 x

05 cm), S2- (30 x 10 cm) and Main plot(B): Varieties V1-JS-9560 (extra early 80-85 days), V2- JS-9305 (early 90-85 days) and V3-JS-9752 (medium 98-102 days) and sub plot nutrient schedule N1- 50%RDF, N2-75% RDF, N3- 100%RDF (30:75:30 NPK kg/ha) and N4-125%RDF with 3 replications at Regional Research Station, Amravati under Dr.PDKV, Akola. The soil was medium black. The plot size Gross: 5.00 x 3.60 m and net plot size was 4.80 x 2.70 m. The recommended fertilizer dose of 30:75:30 NPK kg/ha was applied through straight fertilizers. The seeds were sown by dibbling. The seed yield and quality attributes were recorded during the crop growth and after harvest. The data obtained were analysed through analysis of variance (ANOVA) technique for factorial randomized block design and presented at 5% level of significance ($P = 0.05$) suggested by Panse and Sukhatme.

Result sand Discussion

Plant Height

Pooled data over the three years in respect of plant height revealed that spacing showed non-significant effect whereas variety JS-9752 recorded significantly higher plant height (53.66cm) as compare to variety JS-9560 but at par with variety JS-9305.

Application of 100% RDF (N_3) recorded significantly more plant height (53.87cm) over rest of the nutrient management treatments in pooled results.

Table 1: Plant Height (cm) and number of branches /palnt of soybean as influenced by Spacing, Varieties and Nutrient management.

Treatments	Plant height (cm)				Number of branches per plant			
	2017-18	2018-19	2019- 20	Pooled	2017-18	2018-19	2019- 20	Pooled
Main Plot (A): Spacing								
S1: 45x05 cm	50.17	44.36	51.57	47.46	2.92	2.98	3.90	3.22
S2: 30x10 cm	50.78	45.85	55.15	51.84	2.87	2.90	3.71	3.20
SE $\pm$ (m)	1.27	0.98	1.14	1.41	0.05	0.04	0.11	0.14
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS
(B): Varieties								
V1: JS-9560(Extra early 80-85 days)	45.08	42.68	47.12	46.47	2.73	2.78	3.34	2.95
V2: JS-9305 (Early 90-95 days)	51.96	44.22	50.93	48.82	2.88	2.92	3.36	3.06
V3: JS-9752 (Medium 98-102 days)	54.39	48.43	62.04	53.66	3.08	3.10	4.71	3.63
SE $\pm$ (m)	1.56	1.20	1.40	1.73	0.06	0.05	0.13	0.17
CD at 5%	4.92	3.78	4.41	5.44	0.21	0.15	0.42	0.53
Sub Plot: Nutrient Schedule								
N1: 50% RDF	46.44	41.95	47.27	45.22	2.46	2.51	3.25	2.74
N2: 75% RDF	50.06	43.12	50.29	47.83	2.72	2.76	3.57	3.02
N3: 100% RDF	53.99	49.24	58.38	53.87	3.41	3.44	4.23	3.70
N4: 125% RDF	51.41	46.11	57.50	51.68	2.99	3.04	4.15	3.39
SE $\pm$ (m)	1.76	0.81	0.83	0.72	0.06	0.07	0.12	0.08
CD at 5%	5.06	2.33	2.37	2.06	0.19	0.21	0.34	0.24
Interaction								
S x V								
SE $\pm$ (m)	2.20	1.69	1.97	2.44	0.09	0.07	0.18	0.23
CD at 5%	NS	NS	NS	7.69	NS	NS	0.59	NS
S x N								
SE $\pm$ (m)	2.49	1.14	1.16	1.01	0.09	0.10	0.16	0.11
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS
V x N								
SE $\pm$ (m)	3.05	1.40	1.43	1.24	0.11	0.12	0.20	0.14
CD at 5%	NS	NS	4.10	3.56	NS	NS	0.59	NS
S x V x N								
SE $\pm$ (m)	4.32	1.99	2.02	1.75	0.16	0.17	0.29	0.20
CD at 5%	NS	NS	5.80	5.03	NS	NS	0.84	NS

Table 2: Plant height (cm) of soybean as influenced by spacing x variety in pooled

Spacing / Variety	V1	V2	V3
S1	43.41	47.04	51.93
S2	49.52	50.60	55.40
S. E. (m) ±	2.44		
C.D. at 5%	7.69		

Table 3: Plant height (cm) of soybean as influenced by variety x nutrient management in pooled

Variety / Nutrient management	N1	N2	N3	N4
V1	43.20	46.38	48.41	47.42
V2	44.74	46.84	52.99	51.17
V3	47.74	50.26	60.21	56.44
S. E. (m) ±	1.24			
C. D. at 5%	3.56			

Table 4: Plant height (cm) of soybean as influenced by spacing x variety x nutrient management in pooled

Spacing	Variety / Nutrient management	N1	N2	N3	N4
S1	V1	41.00	42.96	44.91	44.79
	V2	41.48	43.39	52.25	51.02
	V3	46.20	48.47	57.76	55.28
S2	V1	45.39	50.73	52.03	49.94
	V2	47.99	49.37	54.96	50.08
	V3	49.29	52.04	62.66	57.59
	S. E. (m) ±	1.75			
	C. D. at 5%	5.03			

Data presented in Table 2 indicated that treatment combination of S2 xV3 (Spacing 45x5 cm with variety JS-9752) showed

significantly higher plant height plant⁻¹ (55.40 cm) over treatment combination S1xV1 and S1xV2 but at par with treatment combination of S1xV3, S2xV1 and S2xV2 in pooled data.

Plant height plant⁻¹ was influenced significantly due to variety and nutrient management combination in pooled data (Table 3). The treatment combination V3xN3 showed significantly more plant height plant⁻¹ (60.21cm) over rest of the treatment combinations.

Plant height was influenced significantly due to spacing x variety x nutrient management interactions in pooled result. Treatment combination S2xV3xN3 showed significantly highest plant height plant⁻¹ (62.66 cm) over other treatment combinations but at par with treatment combination S1xV3 xN3. Gunjal *et al.* (2011) [4] noted that the combined utilization of RDF N: P: K@ (50:75:50 kg ha⁻¹) & FYM @ (5t ha⁻¹) outcome in a slightly maximum plant elevation (69.56 cm) comparison to other treatments.

The plant height enhances with an increase in NPK levels, mainly nitrogen and essential mineral nutrient for plant growth. It is a part of chlorophyll, increases the rate of photosynthesis, imparts green color, and ultimately increases plant growth. Similar results were concluded by Dhadaveet *et al.* (2017) [2].

Three years pooled results revealed that, spacing showed non significant effect whereas significantly highest number of branches per plant was observed in variety JS- 9752 (3.63) as compare to variety JS- 9305 (3.06) and JS- 9560 (2.95).

Application of 100% RDF (N3) recorded significantly highest number of branches per plant (3.70) as compare to other treatments of nutrients management.

Table 6: Number of pods/plant and test weight (g) at harvest of soybean as influenced by spacing, varieties and nutrient management

Treatments	Number of pods per plant				Test weight (g)			
	2017-18	2018-19	2019- 20	Pooled	2017-18	2018-19	2019- 20	Pooled
Main Plot (A): Spacing								
S1: 45x05 cm	16.95	25.46	38.06	26.64	11.22	11.27	10.91	11.12
S2: 30x10 cm	16.90	24.91	37.47	26.61	11.18	11.17	10.87	11.08
SE ±(m)	0.29	030	0.56	0.36	0.12	0.11	0.13	0.10
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS
(B): Varieties								
V1: JS-9560 (Extra early 80-85 days)	16.39	24.32	34.82	25.18	11.56	11.49	11.46	11.50
V2: JS-9305 (Early 90-95 days)	16.54	24.84	38.15	26.50	10.90	10.90	11.89	10.90
V3: JS-9752 (Medium 98-102 days)	17.85	26.39	40.33	28.19	11.15	11.27	10.33	10.91
SE ±(m)	0.36	0.37	0.68	0.44	0.15	0.14	0.16	0.12
CD at 5%	1.15	1.17	2.15	1.39	0.48	0.43	0.49	0.37
Sub Plot: Nutrient Schedule								
N1: 50% RDF	14.48	22.34	34.64	23.82	10.75	10.70	10.38	10.61
N2: 75% RDF	16.06	24.21	36.76	25.68	11.23	11.25	10.56	11.01
N3: 100% RDF	18.77	27.51	39.95	28.73	11.62	11.60	11.59	11.58
N4: 125% RDF	18.40	26.68	39.71	28.26	11.21	11.33	11.04	11.19
SE ±(m)	0.43	0.47	0.63	0.311	0.20	0.21	0.13	0.12
CD at 5%	1.25	1.36	1.81	0.89	0.60	0.60	0.37	0.36
Interaction								
S x V								
SE ±(m)	0.51	0.52	0.96	0.62	0.21	0.19	0.22	0.16
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS
S x N								
SE ±(m)	0.61	0.66	0.89	0.43	0.29	0.29	0.18	0.17
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS
V x N								
SE ±(m)	0.75	0.81	1.09	0.53	0.35	0.36	0.22	0.21
CD at 5%	NS	NS	3.04	1.54	NS	NS	0.64	NS
S x V x N								
SE ±(m)	1.06	1.15	1.54	0.75	0.50	0.51	0.31	0.30
CD at 5%	NS	NS	4.44	2.18	NS	NS	NS	NS

Pooled data over the three years in respect of number of pods per plant at harvest revealed that, spacing showed non significant effect. Significantly highest number of pods per plant was noticed in variety JS-9752 as compare to variety JS-9305 and JS-9560 in pooled data. Treatment of nutrient management 100% RDF recorded significantly highest number of pods per plant (28.73) as compare to treatments N1 and N2 but at par with treatment N4 (28.26).

Number of pods per plant at harvest was influenced significantly due to variety and nutrient management interaction in pooled data (Table 7). The treatment combination V3 x N3 showed significantly more number of pods per plant at harvest (30.81)

over the rest of treatment combination but at par with treatment combination V3 x N4 (29.88).

Table 7: Number of pods per plant at harvest of soybean as influenced by variety x nutrient management in pooled

Variety / Nutrient management	N1	N2	N3	N4
V1	21.17	25.00	27.45	26.35
V2	24.52	25.73	29.04	27.46
V3	25.77	26.31	30.81	29.88
S. E. (m) ±	0.53			
C. D. at 5%	1.54			

Table 8: Number of pods per plant at harvest of soybean as influenced by spacing x variety x nutrient management in pooled

Spacing	Variety / Nutrient management	N1	N2	N3	N4
S1	V1	19.86	25.59	26.81	26.70
	V2	25.70	25.97	28.24	26.70
	V3	25.92	26.86	31.03	30.32
S2	V1	22.48	24.40	25.89	28.21
	V2	23.35	25.48	29.85	28.22
	V3	25.61	25.76	30.58	29.44
S. E. (m) ±		0.75		0.26	
C. D. at 5%		2.18		0.77	

Data presented in table 8, showed that the interaction effect of spacing x variety x nutrient management was significantly influencing the number of pods plant⁻¹. Treatment combination S2xV3xN3 recorded more number of pods per plant (30.58) as compare to rest of all combinations except treatment combination S1xV3xN3, S1xV3xN4, S2xV2xN3 and S2xV3xN4 in pooled result.

Kibiru and Haro (2016) [5] observed that the variety Wello at 60 cm, of crop geometry, was observed the highest quantity of pods plant⁻¹(49.83) in comparison to other treatment interactions.

Singh *et al.* (2013) [9] observed that the integrated use of 125% RDF @ (20:80:40:40 kg NPKS ha⁻¹) registered the maximum

quantity of pods/plant (62.5) relative to other treatments.

From three years pooled data regarding test weight, showed significant results in respect of varieties and nutrient management treatments but spacing noted non significant result. Highest test weight was recorded in variety JS-9560 (11.50 gm) which was significantly higher as compare to variety JS-9305 and JS-9752 in pooled data. Treatment of nutrient management 100% RDF recorded significantly highest test weight (11.58 gm) as compare to treatments N1, N2 and N3.

Singh *et al.* (2013) [9] reviewed that the maximum test weight recorded in a mixed application of 125% RDF @ (20:80:40:40 kg NPKS ha⁻¹) over 100% RDF.

Table 10: Effect of spacing, varieties and nutrient management on seed and straw yield (kg ha⁻¹) of soybean

Treatments	Seed yield (kg ha ⁻¹)				Straw Yield (kg ha ⁻¹)			
	2017-18	2018-19	2019- 20	Pooled	2017-18	2018-19	2019- 20	Pooled
Main Plot (A): Spacing								
S1: 45x05 cm	1636	1660	2161	1819	2043	2068	2869	2327
S2: 30x10 cm	1632	1639	2098	1790	2036	2040	2715	2269
SE ±(m)	26.25	21.43	26.01	22.21	31.95	32.76	52.00	37.21
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS
(B): Varieties								
V1: JS-9560 (Extra early 80-85 days)	1584	1611	1996	1730	1968	1985	2543	2165
V2: JS-9305 (Early 90-95 days)	16.04	1617	2155	1792	2018	2027	2815	2295
V3: JS-9752 (Medium 98-102 days)	1715	1720	2236	1890	2132	2149	3018	2433
SE ±(m)	32.15	26.25	31.85	27.20	39.14	40.12	63.69	45.57
CD at 5%	101.29	82.72	100.37	85.71	123.32	126.41	200.68	143.59
Sub Plot: Nutrient Schedule								
N1: 50% RDF	1396	1441	1984	1607	1732	1731	2390	1951
N2: 75% RDF	1549	1550	2091	1730	1931	1946	2568	2148
N3: 100% RDF	1836	1840	2252	1976	2289	2312	3210	2615
N4: 125% RDF	1756	1766	2189	1903	2206	2226	3001	2478
SE ±(m)	41.81	35.92	49.95	29.99	47.68	44.60	56.56	35.49
CD at 5%	119.92	103.02	143.27	86.02	136.75	127.93	162.23	101.78
Interaction								
S x V								
SE ±(m)	45.46	37.12	45.04	38.46	55.34	56.73	90.06	64.44
CD at 5%	NS	NS	141.95	121.21	NS	NS	283.80	203.06
S x N								
SE ±(m)	59.13	50.79	70.64	42.41	67.42	63.07	79.99	50.18
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS

V x N								
SE ±(m)	72.41	62.21	86.51	51.94	82.58	77.25	97.96	61.46
CD at 5%	NS	NS	248.15	148.99	NS	NS	280.99	176.29
S x V x N								
SE ±(m)	102.41	87.98	122.35	73.46	116.79	109.25	138.54	86.92
CD at 5%	NS	NS	350.94	210.70	NS	NS	397.38	249.31

Pooled data over the three years in respect of seed yield revealed that, spacing showed non significant effect. Variety JS-9752 yielded significantly highest (1890 kg ha⁻¹) as compare to variety JS- 9305 (1792 kg ha⁻¹) and JS- 9560 (1730 kg ha⁻¹).

In pooled data, application of 100% RDF (N3) recorded significantly highest seed yield (1976 kg ha⁻¹) as compare to treatment N1(1607 kg ha⁻¹) and N2(1730 kg ha⁻¹) but at par with treatment N4 i.e. application of 125% RDF (1903 kg ha⁻¹).

Table 11: Seed yield (kg ha⁻¹) of soybean as influenced by spacing x variety in pooled

Spacing / Variety	V1	V2	V3
S1	1774.06	1798.92	1984.08
S2	1686.92	1785.58	1796.90
S. E. (m) ±	38.46		
C. D. at 5%	121.21		

Data presented in Table 11 indicated that treatment combination

of S1xV3 (spacing 45X05 with variety (JS-9752) showed significantly higher seed yield (1984 kg ha⁻¹) over rest of the treatment combinations.

Table 12: Seed yield (kg/ha) of soybean as influenced by variety x nutrient management in pooled

Variety / Nutrient management	N1	N2	N3	N4
V1	1494.61	1667.33	1927.78	1774.40
V2	1594.50	1725.17	1949.56	1856.16
V3	1733.17	1797.86	2081.39	2051.00
S. E. (m) ±	51.94			
C. D. at 5%	148.99			

Seed yield was influenced significantly due to variety and nutrient management interactions in pooled result (Table12).The treatment combination V3xN3 showed significantly highest seed yield (2081 kg ha⁻¹) over the rest of the treatment combinations but at par with treatment combination of V2 x N3 and V3 x N4.

Table 13: Seed yield (kg/ha) of soybean as influenced by spacing x variety x nutrient management in pooled

Spacing	Variety / Nutrient management	N1	N2	N3	N4
S1	V1	1539.78	1677.36	1781.22	1715.33
	V2	1706.00	1746.33	1965.00	1755.98
	V3	1759.67	1868.89	2174.11	2133.67
S2	V1	1449.44	1619.33	1765.44	1871.44
	V2	1483.00	1701.00	2074.33	1956.33
	V3	1706.67	1726.83	2137.00	1988.67
	S. E. (m) ±		73.46		0.26
	C. D. at 5%		210.70		0.77

Seed yield was affected significantly due to interaction between spacing x variety x nutrient management (Table13). Treatment combination S1xV3xN3 recorded significantly highest seed yield (2174 kg ha⁻¹) as compare to rest of all treatment combinations except treatment combination of S1xV2xN3 (1965 kg ha⁻¹), S1xV3xN4 (2133 kg ha⁻¹), S2xV2xN3 (2074 kg ha⁻¹), S2xV3xN3 (2137 kg ha⁻¹), and S2xV3xN4 (1988 kg ha⁻¹) in pooled results respectively.

Raghuveer *et al.* (2015) [7] noted that the maximum crop yield (25.77 kg/ha) found in the treatment integration of nitrogen @ 60 kg/ha & phosphorus @ 80 kg ha⁻¹ with compared to other treatments. Utilization of NPK @ 60:80:25 kg/ha found to be optimal for sustainable crop yield.

Singh *et al.* (2013) [9] noticed that the mixed utilization of 125% RDF @ (20:80:40:40 kg NPKS ha⁻¹) achieved the maximum crop output (24.30 q ha⁻¹ over 100% RDF).

Vyas and Rupendra (2009) [11] observed that cultivar JS 95-60 yielded altogether higher grain yield (22.74 q ha⁻¹) in contrast to JS 97-52 when planted at 45 cm spacing.

The yield was raised with an increase in fertilizer levels. Maximum nitrogen usage leads to rapid leaf area development, extends the life of foliage, increases leaf area duration after flowering and increases crop assimilation ultimately contributing to maximum yield. Soybean is a vital oilseed crop that removes a notable quantity of nutrients from the soil. Soybean has a high P requirement along with S leading to higher and better quality oil production and the shortage of N before to

flower initiation leads to the reduced quantity of pods plant⁻¹, total quantity of seeds pod⁻¹, seed & oil yield. Potassium is the second important nutrient after phosphorus in limiting soybean production. Phosphorus is important for plant development & it is involved in energy transfer, photosynthesis, the transformation of sugars, starch, and nutrient movement within the plant.

Pooled data over the three years in respect of straw yield revealed that, spacing showed non significant effect. Significantly highest straw yield was noticed in variety JS-9752 (2433 kg ha⁻¹) as compare to variety JS-9305 and JS-9560 in pooled data. Treatment of nutrient management 100% RDF recorded significantly highest straw yield (2615 kg ha⁻¹) as compare to treatments N1, N2 and N3.

Table 15: Straw yield (kg ha⁻¹) of soybean as influenced by spacing x variety in pooled

Spacing / Variety	V1	V2	V3
S1	2233.41	2328.14	2554.71
S2	2097.28	2262.69	2312.01
S. E. (m) ±	64.44		
C. D. at 5%	203.06		

Data presented in Table 15 indicated that treatment combination of S1xV3 (Spacing 45X05 with variety JS-9752) showed significantly highest straw yield (2554 kg ha⁻¹) over rest of the treatment combinations.

Table 16: Straw yield (kg ha⁻¹) of soybean as influenced by variety x nutrient management in pooled

Variety / Nutrient management	N1	N2	N3	N4
V1	1695.96	2076.11	2431.59	2381.58
V2	1968.72	2152.27	2666.52	2470.31
V3	2188.63	2216.91	2746.66	2581.23
S. E. (m) ±	61.46			
C. D. at 5%	176.29			

Table 17: Straw yield (kg ha⁻¹) of soybean as influenced by spacing x variety x nutrient management in pooled

Spacing	Variety/Nutrient management	N1	N2	N3	N4
S1	V1	1558.16	2135.34	2368.75	2326.88
	V2	2198.85	2209.59	2490.57	2413.56
	V3	2267.55	2388.14	2891.52	2671.62
S2	V1	1738.59	1942.64	2494.43	2436.28
	V2	1833.75	2045.69	2601.80	2490.84
	V3	2109.72	2169.20	2842.46	2527.07
	S. E. (m) ±		86.92		0.26
	C. D. at 5%		249.31		0.77

Straw yield per hectare was influenced significantly due to variety and nutrient management interactions (Table 16). The

treatment combination V3xN3 showed significantly highest straw yield (2746 kg ha⁻¹) over all treatment combinations but at par with treatment combinations V2xN3 and V3xN4.

Data presented in Table 17 showed that interaction effect of spacing x variety x nutrient management was significantly influencing the straw yield of soybean. Treatment combination S1xV3xN3 recorded highest straw yield (2891 kg ha⁻¹) as compare to rest of all treatment combinations except treatment combination S1xV3xN4, S2xV3xN3 and S2xV3xN4 in pooled result.

Adequate supply of nutrient under 100% RDF favored photosynthetic activity resulting in greater plant height and dry matter aggregation that had finally reflected in maximum straw yield.

Table 18: Gross and net monetary returns (Rs ha⁻¹) and B:C ratio of soybean as influenced by spacing, varieties and nutrient management

Treatments	Gross monetary returns (Rs ha ⁻¹)				Net Monetary Returns (Rs ha ⁻¹)				B:C ratio			
	2017-18	2018-19	2019- 20	Pooled	2017-18	2018-19	2019- 20	Pooled	2017-18	2018-19	2019- 20	Pooled
Main Plot (A): Spacing												
S1: 45x05 cm	49899	56223	74166	60096	22097	28421	43419	31312	1.79	2.02	2.42	2.08
S2: 30x10 cm	49789	55527	71917	59078	21087	27725	41171	30294	1.79	1.99	2.34	2.04
SE ±(m)	800.52	730.08	844.33	776.25	800.52	730.08	844.33	776.25	--	--	--	--
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	--	--	--	--
(B): Varieties												
V1: JS-9560 (Extra early 80-85 days)	48302	54550	68416	57089	20499	26748	37669	28306	1.73	1.96	2.23	1.97
V2: JS-9305 (Early 90-95 days)	48918	54810	73894	59207	21115	27007	43147	30423	1.76	1.97	2.40	2.04
V3: JS-9752 (Medium 98-102 days)	52314	58265	76816	62465	24511	30463	46069	33681	1.88	2.09	2.50	2.16
SE ±(m)	980.43	894.16	1034.09	950.70	980.43	894.16	1034.09	950.70	--	--	--	--
CD at 5%	3089.41	2817.55	3258.47	2995.73	3089.41	2817.55	3258.47	2995.73	--	--	--	--
Sub Plot: Nutrient Schedule												
N1: 50% RDF	42591	48727	67871	53063	15698	48727	38033	25189	1.58	1.81	2.27	1.89
N2: 75% RDF	47236	52530	71582	57116	21298	52530	42699	30196	1.82	2.03	2.31	2.05
N3: 100% RDF	55989	62367	77530	65295	27259	65367	45855	35584	1.95	2.17	2.45	2.19
N4: 125% RDF	53561	59876	75186	62875	23917	59876	42593	32245	1.81	2.02	2.48	2.11
SE ±(m)	1275.25	1209.68	1665.19	959.64	1275.25	1209.68	1665.19	959.64	--	--	--	--
CD at 5%	3657.62	3469.55	4776.04	2752.41	375.62	3469.55	4776.04	2753.41	--	--	--	--
Interaction												
S x V												
SE ±(m)	1960.86	1264.52	1462.42	1344.49	1386.54	1264.52	1462.20	1344.49	--	--	--	--
CD at 5%	NS	NS	4608.18	4236.60	NS	NS	4776.04	4236.60	--	--	--	--
S x N												
SE ±(m)	2550.50	1710.74	2354.93	959.64	1803.47	1710.74	2354.93	1357.14	--	--	--	--
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	--	--	--	--
V x N												
SE ±(m)	3123.71	2095.22	2884.19	1662.15	2208.79	2095.22	2884.19	1662.15	--	--	--	--
CD at 5%	NS	NS	8272.34	4767.31	NS	NS	8272.34	4767.31	--	--	--	--
S x V x N												
SE ±(m)	4417.59	2963.09	4078.87	2350.63	3123.71	2963.09	4078.87	2350.63	--	--	--	--
CD at 5%	NS	NS	11698.85	6742.00	NS	NS	11695.85	6742.00	--	--	--	--

Gross Monetary Returns (Rs ha⁻¹) over the three years pooled data revealed that, spacing showed non significant effect. Highest GMR was recorded with variety JS-9752 (62465 Rs ha⁻¹) which was significantly higher than variety JS-9560 (57089 Rs ha⁻¹) and JS-9305 (59207 Rs ha⁻¹). Application of 100% RDF recorded significantly highest GMR (65295 Rs ha⁻¹) as compare to other treatments of nutrient managements but at par with treatment N4 i.e. 125% RDF (62875 Rs ha⁻¹).

Table 19: Gross Monetary Returns (Rs ha⁻¹) of soybean as influenced by spacing x variety in pooled

Spacing / Variety	V1	V2	V3
S1	58538.53	59375.04	65608.94
S2	55640.48	59039.42	59321.28
S. E. (m) ±	1344.49		
C. D. at 5%	4236.60		

Data presented in Table 19 indicated that treatment combination of S1xV3 showed higher GMR (65608 Rs ha⁻¹) and found to be

significantly superior over rest of the treatment combinations.

Table 20: Gross Monetary Returns (Rs ha⁻¹) of soybean as influenced by variety x nutrient management in pooled

Variety / Nutrient management	N1	N2	N3	N4
V1	49254.97	55068.99	63580.79	58581.05
V2	52671.54	56941.20	64548.73	61331.76
V3	57263.34	59337.37	68711.00	67756.64
S. E. (m) ±	1662.15			
C. D. at 5%	4767.31			

Gross monetary returns was influenced significantly due to variety and nutrient management interactions in pooled result (Table 20). The treatment combination V3 x N3 showed

significantly highest GMR (68711Rs ha⁻¹) as compare to other treatment combinations but at par with treatment combination of V2 x N3 and V3 x N4 in pooled data.

Table 21: Gross Monetary Returns (Rs ha⁻¹) of soybean as influenced by spacing x variety x nutrient management in pooled

Spacing	Variety / Nutrient management	N1	N2	N3	N4
S1	V1	50646.79	55347.42	58835.04	56724.87
	V2	56414.42	57732.68	64890.82	58127.58
	V3	58180.41	61755.30	71775.91	70724.13
S2	V1	47863.15	53413.10	61814.69	58373.33
	V2	48928.66	56149.73	68326.54	64535.94
	V3	56346.26	56919.44	70622.46	65646.08
	S. E. (m) ±		2350.63		0.26
	C. D. at 5%		6742.00		0.77

Gross monetary returns was affected significantly due to interaction between spacing x variety x nutrient management (Table 21). Treatment combination S1xV3xN3 recorded significantly highest GMR (71775 Rs ha⁻¹) as compare to rest of all treatment combinations except treatment combination of S1xV3xN4 (70724 Rs ha⁻¹), S2xV3xN3 (68326 Rs ha⁻¹), S2xV3xN3 (70622 Rs ha⁻¹) and S2xV3xN4 (65646 Rs ha⁻¹) in pooled results respectively.

Net Monetary Returns (Rs ha⁻¹) over the three years pooled data revealed that, spacing showed non-significant effect. Highest NMR was recorded with variety JS-9752 (33681 Rs ha⁻¹) which was significantly higher than variety JS-9560 (28306 Rs ha⁻¹) but at par with variety JS-9305 (30423 Rs ha⁻¹). Application of 100% RDF recorded significantly highest NMR (35584 Rs ha⁻¹)

as compare to other treatments of nutrient managements.

Table 23: Net Monetary Returns (Rs ha⁻¹) of soybean as influenced by spacing x variety in pooled

Spacing / Variety	V1	V2	V3
S1	26856.56	30255.51	36825.02
S2	29754.61	30591.12	30537.36
S. E. (m) ±	1344.49		
C. D. at 5%	4236.60		

Data presented in Table 23 indicated that treatment combination of S1xV3 showed higher NMR (36825 Rs ha⁻¹) and found to be significantly superior over rest of the treatment combinations.

Table 24: Net Monetary Returns (Rs ha⁻¹) of soybean as influenced by variety x nutrient management in pooled

Variety / Nutrient management	N1	N2	N3	N4
V1	21380.30	30021.54	33869.12	27951.39
V2	24796.88	28149.32	34837.06	30702.09
V3	29388.67	32417.70	38081.33	38044.97
S. E. (m) ±	1662.15			
C. D. at 5%	4767.31			

Net monetary returns was influenced significantly due to variety and nutrient management interactions in pooled result (Table 24). The treatment combination V3 x N3 showed significantly

highest NMR (38081 Rs ha⁻¹) as compare to other treatment combinations but at par with treatment combination of V1 x N3, V2 x N3 and V3 x N4 in pooled data.

Table 25: Net Monetary Returns (Rs ha⁻¹) of soybean as influenced by spacing x variety x nutrient management in pooled

Spacing	Variety / Nutrient management	N1	N2	N3	N4
S1	V1	22772.12	29123.37	29805.21	24717.75
	V2	27497.91	28539.76	35179.15	30813.01
	V3	30305.75	33835.64	41146.24	41012.46
S2	V1	19988.48	26493.43	31185.02	28661.66
	V2	21054.00	29230.06	38614.88	33906.28
	V3	28471.60	29999.77	40910.79	35016.41
	S. E. (m) ±		2350.63		0.26
	C. D. at 5%		6742.00		0.77

Net monetary returns was affected significantly due to interaction between spacing x variety x nutrient management (Table 25). Treatment combination S1xV3xN3 recorded significantly highest NMR (41146 Rs ha⁻¹) as compare to rest of all treatment combinations except treatment combination of S1xV2xN3 (35179 Rs ha⁻¹), S1xV3xN4 (41012 Rs ha⁻¹), S2xV2xN3 (38614 Rs ha⁻¹), S2xV3xN3 (40910 Rs ha⁻¹) and S2xV3xN4 (35016 Rs ha⁻¹) in pooled results respectively. Over the three years pooled data reveals that, highest B:C ratio was recorded with spacing of 45x05 (2.08) in variety JS-9752 (2.16) with nutrient management of application of 100% RDF (2.19).

Faizrahman *et al.* (2015) [3] observed that the highest net profit (62,258 ₹ ha⁻¹) & B:C ratio (4.56) achieved by cultivating mash-2008 variety over other varieties in the treatment and in terms of crop geometry 30 cm x 10 cm shown maximum net return (56,809 ₹ ha⁻¹) & B: C ratio (4.22).

Sujoyb and Vanita (2013) [10] studied and revealed that soybean cultivation in Maharashtra was a profitable enterprise as the returns per rupee invested be 1.08 on an overall basis, varying from 1.13 on small farms to 1.14 on large farms.

Devi *et al.* (2013) [1] noticed that the highest net return (59,349 ₹ ha⁻¹) & B: C ratio observed in the combined use of 75% RDF @ 40:60:20 kg NPK ha⁻¹ over 100% RDF.

Sowing of the crop with optimum plant spacing led to increase in gross returns, net profit and B: C ratio due to higher seed yield and straw yield. Higher gross returns, net profit and B:C ratio with maximum level of nutrients has been reported by Patel and Patel (2013) [6].

Results

From pooled data over the three years revealed that, spacing showed non significant effect. In varietal comparison variety JS-9752 (V3) yielded significantly superior (1890 kg ha⁻¹) as compare to variety JS-9560 (1730 kg ha⁻¹) and JS-9305 (1792 kg ha⁻¹). In case of straw yield variety JS-9752 (2433 kg ha⁻¹) recorded significantly superior straw yield over JS-9560 (2165 kg ha⁻¹) and JS-9305 (2295 kg ha⁻¹). Variety JS-9752 showed significantly higher Gross monetary returns and B:C ratio as compare to other varieties but at par with variety JS-9305 in case of Net monetary returns.

Nutrient management treatment N3 (100% RDF) recorded significantly higher seed yield i.e. 1976 kg ha⁻¹ over the treatment N1 and N2 but at par with N4 (1903 kg ha⁻¹). Significantly highest straw yield was recorded in treatment 100% RDF (2615 kg ha⁻¹) as compare to treatments N1, N2 and N3. Nutrient management treatment N3 (100% RDF) showed significantly higher Gross monetary return (65295 Rs ha⁻¹), Net monetary return (35584 Rs ha⁻¹) and B:C ratio (2.19) as compare to rest of the nutrient management treatments but at par with treatment N4 i.e. 125% RDF in case of GMR.

Treatment combination of S1xV3 (spacing 45X05 with variety JS-9752) showed significantly higher seed yield (1984 kg ha⁻¹), straw yield (2554 kg ha⁻¹), GMR (65608 Rs ha⁻¹) and NMR (36825 Rs ha⁻¹) over rest of the treatment combinations.

Variety JS-9752 and nutrient management 100% RDF recorded significantly highest seed yield (2081 kg ha⁻¹), straw yield (2746 kg ha⁻¹) GMR (68711 Rs ha⁻¹) and NMR (38081 Rs ha⁻¹) over all other treatment combinations but at par with treatment combinations V2xN3 and V3xN4. Treatment combination of V3 x N3 was at par with V1xN3 in respect of NMR in pooled data. Treatment combination S1xV3xN3 recorded significantly highest seed yield (2174 kg ha⁻¹), straw yield (2891 kg ha⁻¹), GMR (71775 Rs ha⁻¹) and NMR (41146 Rs ha⁻¹) as compare to

rest of all treatment combinations except treatment combination of S1xV3xN4, S2xV3xN3 and S2xV3xN4 but treatment combination S1xV3xN3 was also found at par with S2xV2xN3, S2xV2xN4 in respect of seed yield, S2xV2xN3 in respect of GMR and S1xV2xN3, S2xV2xN3 in respect of NMR in pooled results respectively.

Treatment combination S1xV3xN3 recorded numerically highest seed yield (2174 kg ha⁻¹), straw yield (2891 kg ha⁻¹), GMR (71775 Rs ha⁻¹) and NMR (41146 Rs ha⁻¹) as compare to rest of all treatment combinations.

Conclusion

For getting higher yield and net monetary returns from medium duration variety of soybean, it is recommended that sowing should be done at spacing 45 x 05 cm with application of 100% RDF (30:75:30 NPK kg ha⁻¹).

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