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Effect of plant spacings and number of seeds dibble^{-1} on nutrient uptake, quality, yield and soil properties of *kharif* soybean (*Glycine max* L. Merrill)

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Abstract
A field experiment entitled, "Optimization of seed rate and spacing of soybean (*Glycine max*. L. Merrill) during *kharif* season" was conducted at PG Research Farm, Agronomy Section, RCSM College of Agriculture, Kolhapur during *kharif* 2018 to evaluate different treatments on nutrient status and soil properties. The treatments consisting of four plant spacings *viz.*, 30 x 5 cm^2, 30 x 10 cm^2, 45 x 5 cm^2 and 45 x 10 cm^2 and three seed rates *viz.*,D_1 (One seed dibble^{-1}), D_2 (Two seeds dibble^{-1}) and D_3 (Three seeds dibble^{-1}). Mean total uptake of N, P and K and available N, P and K was influenced significantly by different plant spacing as well as number of seeds dibble^{-1}. The uptake of N, P and K in soybean was highest in plant spacing 30 x 5 cm2 followed by plant spacing 30 x 10 cm2. Numerically available NPK in soil was increased with increase in plant spacing. It was higher at plant spacing 45 x 10 cm2 than other plant spacings. Highest available N, P and K was recorded in plant spacing 45 x 10 cm2 followed by plant spacing 45 x 5 cm2. Among the number of seeds dibble^{-1} the uptake of N, P and K was highest in sowing of three seeds dibble^{-1} followed by sowing of two seeds dibble^{-1}. The available N, P and K was higher at sowing of one seed dibble^{-1} followed by sowing of two seeds dibble^{-1}.
The seed yield were higher at plant spacing 45 x 5 cm^2 produced seed yield (26.46 q ha^{-1}) and stover yield (39.20 q ha^{-1}) it was followed by plant spacing 45 x 10 cm^2 produced seed yield (24.83 q ha^{-1}) and stover yield (38.79 q ha^{-1}). Significantly Sowing of two seeds dibble^{-1} produced highest seed yield (26.90 q ha^{-1}) and stover yield (40.46 q ha^{-1}) and it was followed by one seed dibble^{-1} with produced seed yield (25.53 q ha^{-1}) and stover yield (39.48 q ha^{-1}).

Keywords: Plant spacings and no. of seeds per dibble, uptake, quality, yield and soybean

Introduction
Soybean (*Glycine max* (L.) Merrill) is known as leguminous crop and belongs to family Leguminosae. It has Eastern Asian origin. Soybean was cultivated in China from 3000 B. C. It is the miracle crop and has witnessed phenomenal growth in production, processing and trade in last few years in India and has revolutionized the rural economy and improved socio economic status of farmers. Soybean cultivation has placed India on the world map in recent past. Soybean has not only gained the vital importance in Indian agriculture, but also plays an important role in oil economy of India
Among the various factors spacing is one of the important factor which ultimately affected nutrients uptake, growth and yield of plant. The increase or decrease of row spacing and plant population has definite pattern in relation to the yield. Farmers in the western Maharashtra especially in Kolhapur different where, soybean is followed by sugarcane under irrigated condition prefer dibbling soybean on ridges and furrow method. Under such situation row to row spacing varies and number of seeds dibbled hill^{-1} also varies from 1 to 4 seeds hill^{-1} where very high seed rate are used. More scientific effort needed to increase the productivity of soybean per unit area, and per unit time with optimum plant population. It is necessary to maintain optimum plant population to get higher productivity. Therefore, the present investigation was undertaken to study Optimization of seed rate and spacing of soybean (*Glycine max*. L. Merrill) during *kharif* season.

Materials and methods

An experiment to study Optimization of seed rate and spacing of soybean (*Glycine max*. L. Merrill) during *kharif* season was conducted at PG Research Farm, Agronomy Section, RCSM College of Agriculture, Kolhapur during kharif 2018. The soil of the experimental plot was clayey in texture, low in available nitrogen (207.20 kg ha^{-1}), medium in available phosphorus (28.75 kg ha^{-1}) and high in available potassium (287.05 kg ha^{-1}). The soil was slightly alkaline in reaction (pH 7.75). The field experiment was laid out in split plot design with three replications and 12 treatment combinations consist of four plant spacings *viz.,* 30 x 5 cm^2, 30 x 10 cm^2 , 45 x 5 cm^2 and 45 x 10 cm^2, and three seed rates *viz.,*D_1 (One seed $dibble^{-1}$), D_2 (Two seeds $dibble^{-1}$) and D_3 (Three seeds $dibble^{-1}$). The plot size was 5.40 m x 4.50 m and 4.50 m x 3.60 m as the gross and net plot, respectively.

The soybean seeds were treated with biofetilizer *Rhizobium japonicum* and PSB @ 250 g 10 kg^{-1} seed. Sowing was done with the help of marker at a distance of 45 cm and 30 cm between the rows and 5 and 10 cm spacing between the plants as per treatments. The seed was sown at 5 cm depth by dibbling. The fertilizer was applied as a basal application by using urea, single super phosphate (SSP) and muriate of potash (MOP) as sources for nitrogen, phosphorus and potash respectively.

Results and discussion

I) Effect of plant spacings and number of seeds $dibble^{-1}$ on total NPK uptake

NPK uptake kg ha^{-1} was increased with decrease in plant spacing it was significantly higher at plant spacing 30 x 5 cm^2 over rest of the plant spacings, similarly NPK uptake kg ha^{-1} at plant spacing 30 x 5 cm^2 was significantly higher over plant spacing 30 x 10 cm^2,45 x 5 cm^2 and 45 x 10 cm^2 Similar result was also reported by Khazi *et al.* (2013) [5].

NPK uptake kg $ha^{-1}$was increased with increase plant population. NPK uptake kg ha^{-1} was significantly highest at sowing of three seeds $dibble^{-1}$ over two seeds $dibble^{-1}$ and one seed $dibble^{-1}$.

II) Effect of plant spacings and number of seeds $dibble^{-1}$ on available NPK in soil

Different plant spacings and number of seeds per $dibble^{-1}$ had no significant effect on available NPK. Numerically higher available NPK was found in plant spacing 45 x 10 cm^2 followed by plant spacing 45 x 5 cm^2. This was probably due to the more competition for these nutrient leads to higher extraction of nutrients. Similar result was also reported by Khazi *et al.* (2013) [5].

Number of seeds per $dibble^{-1}$ had no significant effect on available NPK. Numerically higher available NPK was found in sowing of one seed $dibble^{-1}$ followed by sowing two seeds $dibble^{-1}$. This was probably due to less competition among plants for nutrients.

III) Effect of plant spacings and number of seeds $dibble^{-1}$ on oil content in seed (%) and oil yield (kg ha^{-1})

The oil content in seed and oil yield as influenced by different treatment were presented in Table No 3. Different plant spacings and number of seeds per $dibble^{-1}$ had no significant effect on oil content in seed. Numerically higher oil content in seed was found in plant spacing 45 x 5 cm^2 followed by plant spacing 45 x 10 cm^2. The oil yield were recorded highest in plant spacing 45 x 5 cm^2 followed by plant spacing 45 x 10 cm^2. This might be attributed to less competition for nutrition seems to be involved in an increasing the rate of conversion of primary fatty acid metabolites to end products of fatty acid resulting in higher oil content in seeds.

Number of seeds per $dibble^{-1}$ had no significant effect on oil content in seed. Numerically higher oil content in seed was found sowing of one seed $dibble^{-1}$ followed by sowing of two seeds $dibble^{-1}$. The oil yield was recorded highest in sowing of one seed $dibble^{-1}$ followed by sowing of two seeds $dibble^{-1}$. Increases in oil content might be attributed to balanced nutrition seems to be involved in an increased conversion of primary fatty acid metabolites to end products of fatty acid resulting in higher oil content in seeds.

IV) Effect of plant spacings and number of seeds $dibble^{-1}$ on protein content in seed (%) and protein yield (kg ha^{-1})

The protein content in seed and protein yield as influenced by different treatment were presented in Table No 3. Different plant spacings and number of seeds per $dibble^{-1}$ had no significant effect on protein content in seed. Numerically higher protein content in seed was found in plant spacing 45 x 5 cm^2 followed by plant spacing 45 x 10 cm^2. The protein yield were recorded highest in plant spacing 45 x 5 cm^2 followed by plant spacing 45 x 10 cm^2. Lowest protein content was recorded in plant spacing 30 x 5 cm2 this was due to more competition for N uptake in higher plant density leads to lower protein content at higher plant density.

Number of seeds per $dibble^{-1}$ had no significant effect on protein content in seed. Numerically higher protein content in seed was found sowing of one seed $dibble^{-1}$ followed by sowing of two seeds $dibble^{-1}$. The protein yield was recorded highest in sowing of one seed $dibble^{-1}$ followed by sowing of two seeds $dibble^{-1}$ this was probably due to less uptake of nitrogen at lower nitrogen level.

V) Effect of plant spacings and number of seeds $dibble^{-1}$ on seed yield, stover yield and harvest index of *kharif* soybean soybean at harvest

Plant spacing 45 x 5 cm^2 recorded maximum seed yields (26.46 q ha^{-1}) and stover yield (39.20 q ha^{-1}) which was significantly superior over rest of the plant spacings however, on par with plant spacing 45 x 10 cm^2 which produce seed yield (24.83 q ha^{-1}) and stover yield (38.79 q ha^{-1}). Higher seed yield at highest plant population level was due to more pods per unit area. Seed yield is positively related to photosynthetically active radiation (PAR) interception (Wells *et al.*, 1993; De bruin and Pedersen, 2009). Therefore, at higher plant population more interception of PAR is expected to increase seed yield and this could be the reason for higher yield at higher plant population in the present study. Highest harvest index was recorded at plant spacing 45 x 5 cm^2 followed by plant spacing 45 x 10 cm^2 and lowest harvest index was recorded at plant spacing 30 x 5 cm^2. These results are in accordance with Sarmah and kalita, (1982), Balyan and Mehta (1985) Goyal *et al*., (2008), Rajput *et al.,* (1985) [10] Pople (1986) [8].

Sowing of two seeds $dibble^{-1}$ (26.90 q ha^{-1}) recorded the maximum seed yield, which was significantly superior over sowing three seeds $dibble^{-1}$ (22.35 q ha^{-1}), while it was on par with sowing of one seed $dibble^{-1}$ (25.53 q ha^{-1}). Sowing of two seeds $dibble^{-1}$ recorded maximum stover yield (40.46 q ha^{-1}), biological yield (67.36 q ha^{-1}) and harvest index which was significantly superior over sowing of three seeds $dibble^{-1}$ while, it was on par with sowing of one seed $dibble^{-1}$.

Table 1: Effect of plant spacings and number of seeds dibble^{-1} on nutrient uptake of *kharif* soybean at harvest

Treatments	Nutrient uptake (kg ha^{-1}) by seed and stover		
	Nitrogen (kg ha^{-1})	Phosphorous (kg ha^{-1})	Potassium (kg ha^{-1})
Main Plot: Spacings			
S_1- 30 cm x 5 cm	213.31	33.73	113.48
S_2- 30 cm x 10 cm	204.96	32.28	108.99
S_3- 45 cm x 5 cm	196.89	30.72	97.82
S_4- 45 cm x 10 cm	192.79	28.57	94.78
S. Em±	3.96	0.84	2.71
C. D. at 5%	13.72	2.91	9.39
Sub Plot: No. of seeds per dibble			
D_1 - One seed dibble^{-1}	195.28	30.17	99.94
D_2 - Two seeds dibble^{-1}	201.67	31.25	103.56
D_3 - Three seeds dibble^{-1}	209.01	32.56	108.52
S. Em±	3.07	0.59	1.77
C. D. at 5%	9.21	1.76	5.32
Interactions: S × D			
S. E m±	6.15	1.17	3.50
C. D. at 5%	NS	NS	NS
General mean	201.99	31.32	103.94

Table 2: Effect of plant spacings and number of seeds dibble^{-1} on mean available nitrogen, phosphorus and potassium at harvest

Treatments	Available nitrogen (kg ha^{-1})	Available phosphorous (kg ha^{-1})	Available potassium (kg ha^{-1})
Main Plot: Spacings			
S_1- 30 cm x 5 cm	205.38	29.97	265.93
S_2- 30 cm x 10 cm	207.77	30.66	267.89
S_3- 45 cm x 5 cm	211.88	31.16	275.20
S_4- 45 cm x 10 cm	216.49	32.66	277.17
S. Em±	2.63	0.57	2.71
C. D. at 5%	NS	NS	NS
Sub Plot: No. of seeds per dibble			
D_1 - One seed dibble^{-1}	215.01	31.69	273.87
D_2 - Two seeds dibble^{-1}	208.65	30.93	273.52
D_3 - Three seeds dibble^{-1}	207.48	30.73	267.25
S. Em±	2.20	0.33	2.03
C. D. at 5%	NS	NS	6.10
Interactions: S × D			
S. E m±	4.40	0.66	4.07
C. D. at 5%	NS	NS	NS
General mean	210.38	31.11	271.55

Table 3: Effect of Plant spacings and number of seeds dibble^{-1} on oil content in seed, oil yield and protein content in seed and protein yield of soybean

Treatments	Oil content in Seed (%)	Oil yield (kg ha^{-1})	Protein content in Seed (%)	Protein yield (kg ha^{-1})
Main Plot: Spacing				
S_1- 30 cm x 5 cm	17.42	418.33	38.60	928.78
S_2- 30 cm x 10 cm	17.76	435.10	39.46	962.99
S_3- 45 cm x 5 cm	18.43	486.44	42.41	1125.61
S_4- 45 cm x 10 cm	18.37	456.70	40.32	1001.42
S. Em±	0.52	13.44	0.86	36.65
C. D. at 5%	NS	46.52	NS	126.82
Sub Plot: No. of seeds dibble^{-1}				
D_1 – One seed dibble^{-1}	18.68	476.88	42.05	1076.95
D_2 – Two seeds dibble^{-1}	17.89	480.98	39.63	1066.96
D_3 –Three seeds dibble^{-1}	17.42	389.57	38.91	870.19
S. Em±	0.36	10.67	0.87	29.19
C. D. at 5%	NS	32.00	NS	87.52
Interaction: S × D				
S. Em±	0.71	21.34	1.75	58.38
C. D. at 5%	NS	NS	NS	NS
General mean	18.00	449.14	40.20	1004.70

Table 4: Effect of Plant spacings and number of seeds dibble^{-1} on yield and harvest index of soybean

Treatments	Seed yield (q ha^{-1})	Stover yield (q ha^{-1})	Harvest Index (%)
Main Plot: Spacings			
S_1- 30 cm x 5 cm	24.04	37.80	38.87
S_2- 30 cm x 10 cm	24.39	38.28	38.89
S_3- 45 cm x 5 cm	26.46	39.20	40.21
S_4- 45 cm x 10 cm	24.83	38.79	39.05
S. Em±	0.48	0.36	0.55
C. D. at 5%	1.67	1.23	1.89
Sub Plot: No. of seeds per dibble			
D_1 - One seed dibble $^{-1}$	25.53	38.70	39.48
D_2 - Two seeds dibble $^{-1}$	26.90	40.46	38.29
D_3 - Three seeds dibble $^{-1}$	23.35	37.63	37.91
S. Em±	0.46	0.86	0.78
C. D. at 5%	1.39	2.58	2.34
Interactions: S × D			
S. Em±	0.93	1.72	1.56
C. D. at 5%	NS	NS	NS
General mean	25.07	38.69	39.24

Conclusion

1. Among the plant spacings sowing of soybean at 45 x 5 cm^2 (4,44,444 plants ha^{-1}) plant spacing recorded the highest uptake of NPK and produced higher ouality parameters.
2. Among the number of seeds dibble^{-1} sowing of soybean at one seed dibble^{-1} produced higher oil and protein yield.

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