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RESEARCH NOTE

Performance of soybean genotypes at varying plant population under delayed onset of mansoon

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Abstract: A field experiment was carried out at the MARS, Dharwad during *kharif* 2017 to study the performance of soybean genotypes at varying plant population levels under delayed monsoon conditions. In the study, genotype DSb-32 recorded significantly higher dry matter in pods (18.91 g plant^{-1}) while DSb-31 (25.17 g plant^{-1}) and DSb-32 (27.93 g plant^{-1}) produced considerably higher total dry matter. Plant population level of 3.33 lakhs plants ha^{-1} + RDF + mycorrhizal consortium (16.91 g plant^{-1}& 24.93 g plant^{-1}) and 4.20 lakhs plants ha^{-1} + RDF + mycorrhizal consortium (16.31 g plant^{-1} & 24.15 g plant^{-1}) accumulated significantly higher dry matter in pods as well as total dry matter production than the rest. Genotypes DSb-31 and DSb-32 recorded similar AGR and NAR values while at low plant population considerably higher NAR was recorded over the rest. The number of pods per plant, seeds per pod, grain yield per plant and total grain yield was found to be significantly superior with genotype DSb-32. Grain yield at 3.33 lakhs plants ha^{-1} + RDF + mycorrhizal consortium (20.69 q ha^{-1}), 4.20 lakhs plants ha^{-1} + RDF + mycorrhizal consortium (19.94 q ha^{-1}) and 5.00 lakhs plants ha^{-1} + RDF + mycorrhizal consortium (19.61 q ha^{-1}) yielded similar results which was significantly superior to seed yield of 3.33 lakhs plants ha^{-1} + RDF (15.75 q ha^{-1}).

Keywords: Absolute growth rate, Genotype, Monsoon, Net assimilation rate

Under delayed onset of monsoon, contingency crop practices such as increasing the plant density, selection of suitable genotypes, use of anti transpirants/mulches and inoculation with mycorrhizal consortium can help to cope up the loss by stabilizing crop stand, production and income in rainfed regions. Choosing of appropriate genotypes for a particular agro-climatic condition is imperative to achieve maximum potential as a result of their differential growth and development pattern.With the release of new improved soybean varieties, knowledge on their potential and performance under different cultural practices are required.

In soybean, optimum plant spacing is essential for achieving optimum plant stand at harvest. An important tool for optimization of crop growth is altering the planting density. This alteration also meets the requirement of time needed for closure of canopy in addition to achieving maximum biomass and seed yield (Liu *et al.,* 2008). Most ideal number of plants per unit area is required for efficient utilization of the available factors of production such as light, nutrients, CO_2 and most importantly water. Exceedingly dense crop is affected by want of space for growth. They have to compete for sunlight, soil moisture and nutrition. Then again, crop planted at low density than the optimum is incapable of producing to its potential, bringing about low yield. By taking into consideration of these factors, it is thus crucial to stick to the most suitable number of plants for a unit area to ensure better yield.

Mycorrhiza enhances water and nutrient transport particularly phosphorus, nitrogen in dry conditions. In addition, other benefits related to mycorrhiza are the stabilization of soil aggregates, increased resistance to water stress and protection against pathogens. So to improve the crop yield, right amount of mycorrhiza is to be incorporated that can help to meet the applied fertilizer efficiency. Considering the above facts, this experiment was conducted.

The experiment was conducted at the Main Agricultural Research Station, UAS, Dharwad during *kharif* 2017. The soil type was medium black clayey with pH of 7.3 and organic carbon of 0.52 per cent and available N, P and K of 268, 31 and 302 kg ha^{-1}, respectively. A total rainfall of 420.4 mm was received during the crop growing period. The experiment was laid out in split plot design, consisting of four genotypes as main plots, four population levels as sub plots and replicated thrice.There were sixteen treatments, main plot consisted of DSb-31 (G_1), DSb-32 (G_2), DSb-21 (G_3) and JS 93-05 (G_4) and sub-plot consisted of 3.33 lakhs plants ha^{-1} + RDF + Mycorrhizal consortium (P_1), 4.20 lakhs plants ha^{-1} + RDF + Mycorrhizal consortium (P_2), 5.00 lakhs plants ha^{-1} + RDF + Mycorrhizal consortium (P_3) and 3.33 lakhs plants ha^{-1} + RDF (P_4). The required plant population were maintained by keeping spacing of P_1- 30 × 10 cm, P_2- 30 × 8 cm, P_3 -30 × 6.6 cm and P_4 - 30 × 10 cm. The crop was sown on 26th July 2017. Entire dose of fertilizers were applied at the time of sowing and other necessary practices were followed as per the package of practices (Anon., 2018). Biometrical observations were recorded from five randomly selected plants from net plots. Absolute growth rate (AGR) for 60-90 DAS and Net assimilation rate (NAR) for 30-60 DAS was calculated using following formulas:

$$\text{AGR (g day}^{-1}) = \frac{W_2 - W_1}{t_2 - t_1}$$

$$\text{NAR (g cm}^{-2}\text{ day}^{-1}) = \frac{W_2 - W_1}{t_2 - t_1} \times \frac{\log_e W_2 - \log_e W_1}{L_2 - L_1}$$

Where, W_1 and W_2 are dry weights of plants in grams at time t_1 and t_2, respectively.

L_1 and L_2 are leaf area of plant at time t_1 and t_2 respectively.

The data collected at different growth stages of crop were subjected to statistical analysis by using Fischer's method of analysis of variance and interpretation of data was done by procedure as described by Gomez and Gomez (1984). The level of significance used in 'F' test was p= 0.05. The mean differences among the treatments were compared by Duncan's Multiple Range Test (DMRT) at 0.05 level of probability.

Growth and physiological studies

At harvest, genotype DSb-32 accumulated significantly higher dry matter in pods (18.91 g plant^{-1}) than the rest while DSb-31 (16.76 g plant^{-1}) was comparable with it. Plant population level of 3.33 lakhs plants ha^{-1} + RDF + mycorrhizal consortium (16.91 g plant^{-1} & 24.93 g plant^{-1}) and 4.20 lakhs plants ha^{-1} + RDF + mycorrhizal consortium (16.31 g plant^{-1} & 24.15 g plant^{-1}) accumulated significantly higher dry matter in pods as well as total dry matter production than the rest.This is because at an optimum plant stand, growth resources are available at an ample quantity allowing the plants at lower density to have more space around them to absorb more nutrients and intercept more solar radiation per plant for better photosynthetic process ensuring excellent performance of individual plants by higher growth rate and dry matter accumulation (Vyas and Khandwe, 2014). At harvest, genotypes DSb-31 (25.17 g plant^{-1}) and DSb-32 (27.93 g plant^{-1}) produced considerably higher total dry matter. The total dry matter produced is a function of overall efficiency of available resource utilization by any genotype in a given period of time.

With respect to AGR and NAR, genotypes DSb-31 (0.275 g day^{-1} & 0.369 mg cm^{-2} day^{-1}, respectively) and DSb-32 (0.281 g day^{-1} & 0.395 mg cm^{-2} day^{-1}, respectively) gave similar results that were considerably higher than the other genotypes. This may be attributed tolarger leaf area, dry matter production and better source-sink relationship leading to better translocation of metabolites and utilization of growth resources in these genotypes.With respect to plant population levels, 3.33 lakhs plants ha^{-1} + RDF + mycorrhizal consortium (0.262 g day^{-1}), 4.20 lakhs plants ha^{-1} + RDF+ mycorrhizal consortium (0.260 g day^{-1}) and 3.33 lakhs plants ha^{-1} + RDF (0.216 g day^{-1}) recorded significantly higher AGR as compared to the 5.00 lakhs plants ha^{-1} + RDF + mycorrhizal consortium (0.186 g day^{-1}). Plant population level of 3.33 lakhs plants ha^{-1} + RDF + mycorrhizal consortium (0.345 mg cm^{-2} day^{-1}) and 3.33 lakhs plants ha^{-1} + RDF only (0.340 mg cm^{-2} day^{-1}) produced considerably higher

Table 1. Growth and physiological characteristics of soybean as influenced by genotypes and plant population levels under delayed monsoon conditions

Treatments	Dry matter accumulation in pods (g plant^{-1})	Total dry matter production per plant (g)	Absolute growth rate at 60-90 DAS (g day^{-1})	Net assimilation rate at 30-60 DAS (mg cm^{-2} day^{-1})
Genotypes				
DSb-31	16.76ab	25.17a	0.275a	0.369a
DSb-32	18.91a	27.93a	0.281a	0.395a
DSb-21	14.26b	20.59b	0.210b	0.241b
JS 93-05	10.55c	13.85c	0.157c	0.185b
S.Em.±	0.81	1.10	0.014	0.034
C.D. (0.05)	2.81	3.79	0.048	0.118
Plant population levels				
3.33 lakhs plants/ha + RDF + Mycorrhizal consortium	16.91a	24.93a	0.262a	0.345a
4.2 lakhs plants/ha + RDF + Mycorrhizal comsortium	16.31a	24.15a	0.260a	0.285b
5.0 lakhs plants/ha + RDF + Mycorrhizal consortium	13.11b	18.20c	0.186b	0.219c
3.33 lakhs plants/ha + RDF	14.14b	20.26b	0.216a	0.340c
S.Em.±	0.43	0.53	0.019	0.016
C.D. (0.05)	1.25	1.56	0.055	0.047

Note: Means followed by the same lower case letters in a column do not differ significantly by DMRT (P=0.05)

Table 2. Grain yield and yield parameters as influenced by genotypes and plant population levels under delayed monsoon conditions

Treatments	Number of pods plant^{-1}	Number of seeds pod^{-1}	Grain yield plant^{-1}(g)	Grain yield (q ha^{-1})
Genotypes				
DSb-31	46.05b	2.90ab	20.33ab	19.36b
DSb-32	51.76a	3.14a	28.61a	23.50a
DSb-21	47.09b	2.45b	14.54b	17.37bc
JS 93-05	28.30c	2.59b	11.72b	15.76c
S.Em.±	1.23	0.14	1.88	0.83
C.D. (0.05)	4.25	0.48	6.51	2.87
Plant population levels				
3.33 lakhs plants/ha + RDF + Mycorrhizal consortium	52.11a	2.85a	25.34a	20.69a
4.2 lakhs plants/ha + RDF + Mycorrhizal consortium	43.32b	2.92a	19.85ab	19.94a
5.0 lakhs plants/ha + RDF + Mycorrhizal consortium	41.28b	2.75a	17.33ab	19.61a
3.33 lakhs plants/ha + RDF	36.50c	2.56a	12.68b	15.75b
S.Em.±	1.23	0.13	1.64	0.35
C.D. (0.05)	3.59	NS	4.79	1.01

Note: Means followed by the same lower case letters in a column do not differ significantly by DMRT (P=0.05)

NAR over the rest. Decreased values of AGR and NAR with increased population level may also be credited to lower dry matter accumulation in leaves coupled with reduction in specific leaf weight (Tirkannavar, 1999).

Yield parameters

Genotype DSb-32 produced considerably more number of pods per plant (51.76), seeds per pod (3.14), grain yield per plant (28.61 g plant^{-1}) and grain yield (23.50 q ha^{-1}) than the other genotypes while JS 93-05 produced significantly lesser values for yield attributes.The superior performance of certain genotypes may be accounted to its varietal inheritance that shows differential growth habit, crop duration and tolerance to pest and diseases (Singh, 2011). Such exceptionally better performance of DSb-32 over other genotypes with respect to yield indicates its distinct superiority.

Among the plant population levels, 3.33 lakhs plants ha^{-1} + RDF + mycorrhizal consortium recorded considerably more number of pods per plant (52.11) and grain yield per plant (25.34 g plant^{-1}) than the rest.The greater availability of resources led to better performance of individual plants and hence higher yield attributes per plant. However population levels did not make a difference on number of seeds per pod thus proving the point that it is a genetical character and a yield parameter which is least impacted by external condition *i.e.* environment.

Grain yield at 3.33 lakhs plants ha^{-1} + RDF + mycorrhizal consortium (20.69 q ha^{-1}), 4.20 lakhs plants ha^{-1} + RDF + mycorrhizal consortium (19.94 q ha^{-1}) and 5.00 lakhs plants ha^{-1} + RDF + mycorrhizal consortium (19.61 q ha^{-1}) yielded similar results which was significantly superior to the seed yield of 3.33 lakhs plants ha^{-1}+ RDF (15.75q ha^{-1}).The ability to retain/ maintain seed yield regardless of the varying population levels (3.33 to 5.00 lakh plants ha$^{–1}$), is likely to be an outcome of the high phenotypic plasticity exhibited by this crop (the fact that soybean has the capacity to compensate space in the canopy and maintain yield) as established by several authors (Board, 2000; De Luca and Hungria, 2014; Pallavi *et al.* 2015; Balbinot *et al.* 2015). Plant population level of 3.33 lakhs plants per ha + RDF produced considerably lesser number of pods (36.50), grain yield per plant (12.68 p plant^{-1}) and grain yield (15.75 q ha^{-1}). This treatment gave a lower yield in spite of maintaining a similar population level because of the absence of mycorrhiza that might have caused decreased availability of phosphorus leading to reduced flowers, pods and seed formation and hence the lower yield.

Conclusion

The study indicated that planting of genotype DSb-32 at 3.33 lakhs plants ha^{-1} + RDF + Mycorrhizal consortium can be advantageous under delayed monsoon conditions for realizing optimum yield.

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