Biological Forum – An International Journal **15(10): 1310-1316(2023)**

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Influence of Sole and Intercropping System on Seed Yield and Quality in Soybean

Gnyandev B.[1]*, Umesh Hiremath[2], Shivakumar B. Bagli[3], Basave Gowda[4], Sunilkumar N.M.[5] and Ningdalli Mallikarjun[6]

[1]Scientist, Seed Science and Technology, ICAR Krishi Vigyan Kendra Bidar, UAS, Raichur (Karnataka), India.
[2]Assistant Professor, Seed Science and Technology, Seed Unit, UAS, Raichur (Karnataka), India.
[3]Senior Research Fellow, Seed Science and Technology, Seed Unit, UAS, Raichur (Karnataka), India.
[4] Registrar, University of Agricultural Sciences, UAS, Bangalore (Karnataka), India.
[5]Senior Scientist and Head, ICAR Krishi Vigyan Kendra Bidar, UAS, Raichur (Karnataka), India.
[6]Scientist, ICAR Krishi Vigyan Kendra Bidar, UAS, Raichur (Karnataka), India.

(Corresponding author: Gnyandev B.)*
(Received: 25 August 2023; Revised: 29 September 2023; Accepted: 07 October 2023; Published: 15 October 2023)
(Published by Research Trend)

ABSTRACT: Globally, cultivable land has decreased due to population increase and industrialization. Industrialization and globalization in agriculture and food supply endanger the future of humanity and environment. A huge amount of energy requires for production the synthetic of fertilizers and pesticides. Moreover, agrochemicals can cause environmental degradation and disruption and human health risks. Many scientists nowadays are getting worried about the environmental and health risks of industrialized agricultural practices, and they are reconsideration low-technology alternatives Sustainable agriculture aims to simulate nature as the pattern for designing agricultural systems an important principle for sustainable agriculture is to create and maintain diversity, integrating plants and animals into a diverse land scape. A sustainable agricultural approach is crop diversification using resource-efficient and lucrative cropping techniques. Intercropping is frequently used by small holders in developing nations to grow crops with increased yield and value. Many intercropping studies have been conducted under experimental conditions, but few studies have been performed in farmers' fields. On farm demonstration with diversified cropping system of soybean + redgram *Vis-a-Vis* farmers' practice of sole soybean was conducted in farmer's field for two years during *Kharif* 2020-21 and 2021-22 in Bidar district, Karnataka to study the influence of sole and intercropping system on seed yield and quality in soybean. The treatments consisted of two factors, Factor-I included two varieties of soybean *viz.*, a) V_1: JS-335 and b) V_2: DSb-21 and Factor-II included Two cropping system a) Intercrop (C_1) and b) Sole crop (C_2). The treatments were laid out in factorial RCBD and replicated thrice. The results revealed that significant difference was noticed between the two soybean varieties grown as sole crop on seed yield and quality parameters except for seedling vigour index, where as in second factor the comparison between sole and intercrop treatment didn't differ significantly which was found to be on par with each other in almost all the parameters except for the yield although there was just slight difference between both the treatments which recorded 2.65 kg per plot and 21.47 q per ha in sole crop (C_2) and 2.50 kg per plot and 20.27 q per ha in intercrop (C_1) and the interaction between the two factors was found to be non significant.

Keywords: Soybean, redgram, intercrop and seed yield.

INTRODUCTION

Sustainable intensification (SI) of agricultural systems is now widely accepted as a guiding principle by progressive farmers, agricultural scientist and agricultural economist such as Baulcombe *et al.* (2009); Antle and Ray (2020). Over the past few decades, interest has grown in the dual objectives of raising food production while also reducing environmental impacts. Increasing production while preserving or improving the services offered by natural ecosystems while utilizing the same amount of inputs or less is known as sustainable intensification of agriculture. Unlike conventional assessments of agricultural productivity, which presuppose that growth is achievable with rising inputs as long as the rise in outputs is also greater (Boult and Chancellor 2020; O'Donnell, 2018).

Intercropping is a pro-environmental practice that supports biodiversity and aligns with the ideals of balanced agriculture. Intercropping has recently being discovered again due to popularity of organic agriculture (Blazewicz-Wozniak and Wach 2011). Intercropping systems are widely used in Latin America, Asia, and Africa where capital investment is restricted, minimizing risk of total crop failure (Legwaila *et al.*, 2012).

Intercropping is proposed as a potential cropping system that is environmentally sound and may solve the conundrum of greater production from 'less' or equivalent land. The act of cultivating two or more crops concurrently in the same field for all or a portion of their growing seasons is known as intercropping. Intercropping can be done in annual and perennial crops alone, as well as between annual and perennial crops mixed together. To increase resource usage efficiency, productivity, and profit per unit of land, it tries to capture the cooperative and facilitative interactions between plant species.

With better economic returns (Mucheru-Muna *et al.,* 2010; van Asten *et al.,* 2011), lower pest and disease incidence (Trenbath 1993; Zhu *et al.,* 2000), and higher land and nutrient use efficiency (Agegnehu *et al.,* 2006; Li *et al.*, 2007), intercropping (IC), an ancient multiple-cropping system, is still popular with smallholder farmers in developing nations. Intercropping is seen by its proponents as a profitable, environmentally friendly, and sustainable cropping technique. Intercropping systems are tough to evaluate because there is frequently uneven competition among the component species across the crop cycle. When crops are produced in an intercropping system, the yield of each species is usually lower than that obtained in sole crop production, even if the sum of relative yields is often greater than one (Yu *et al.,*2015; Martin-Guay *et al.,* 2018). This yield decrease is due to competitive interactions.

In countries like India and Australia where agricultural systems are predominately dominated by intensive monocultures managed in the context of crop rotations and where livestock can be integrated as part of mixed farming enterprises, intercropping systems have not yet been widely adopted by landholders in broad acre production systems (Bybee-Finley and Ryan 2018). This is based on the economic perspective of specialization and economies of scale, which occur when a producer raises the scale of production, hence spreading fixed costs across numerous production units and lowering production costs per unit. Intercropping's economic justification is based on the principle of economies of scope, which develops when a producer may utilize the same inputs to generate two or more goods, lowering the cost of producing them separately.

It is suggested that intercropping would be a practical, ecologically friendly cropping technique that could solve the issue of producing a higher yield from "less" or "equal" land. The act of cultivating two or more crops concurrently in the same field for all or a portion of their growing seasons is known as intercropping. Intercropping can done in annual and perennial crops grown separately as well as when they are grown together. It attempts to capture the complementing and facilitating interactions between species in order to maximize capture, resource efficiency, yield, and profit per unit of land (Dowling *et al*., 2021; Altieri *et al.*, 2012; Sullivan, 2003; Amanullah *et al*., 2016). Intercropping, which is often utilized in smallholder cropping systems, has been demonstrated to increase agricultural productivity, lower economic risk, and lessen negative externalities.

Because intercropping systems are complicated and variable, evaluating them is difficult. To decrease this complexity, a primary system conception with a focus on the possible costs and private and public net advantages of implementing intercropping systems was developed. Intercropping can increase crop yields and profits by improving fertilizer, radiation, and water use efficiency (Cowger and Weisz 2008; Kiær *et al.,* 2009; Lin, 2011; Makate *et al.,* 2016; Sharma *et al.,* 2017; Manevski *et al.,* 2015). Increased groundcover due to intercropping may also reduce runoff and soil erosion (Gou *et al.,* 2016; Hombegowda *et al.,* 2020). Others reported benefits of intercropping include reduction in pest and disease infestation (Johnston *et al.,* 1995; Zhang *et al.,* 2019) increase in soil organic matter, earthworm and soil microbial activity and improvement in soil structure (Ma, 2017; Nyawade *et al.*, 2019, Schmidt *et al.*, 2001; Schmidt *et al*., 2003). Furthermore, incorporating legumes in intercropping promotes nitrogen fixation and improves soil fertility (Nyawade *et al*., 2020; Latati *et al*., 2017) growing crops with different root depths further enhances the efficient use of below-ground resources (Ren *et al.*, 2017; Ren *et al.*, 2019). On-farm crop diversity through intercropping can improve agricultural productivity and stability in the face of seasonal unpredictability and changing climates (Johnston *et al*., 1995; Nieru, 2013). This is because different species react differently under different environmental conditions, so if one species is negatively affected by adverse seasonal weather, other component species within the mixture may still produce a viable yield with the above perspective and positive clues about this system experiment.

Sowing two rows of redgram and four to six rows of groundnut as intercrop by manual sowing. Apart from providing biological insurance, it ensures higher total yield advantage than sole cropping of component crops due to efficient utilization of resources (Andrews, 1972). Soybean inter cropped with redgram is evolved as an alternative sustainable and climate smart cropping system as pigeon pea being a predominantly rainfed crop is one of the most important and potential component of intercropping in semi-arid areas. It is generally intercropped with sorghum, cotton and maize. Soybean is also feasibly intercropped with pigeon pea for enhancing the potential of crop productivity. Keeping in view of the above, a study was conducted with the objective of understanding the seed yield and quality responses of soybean with redgram as intercrop.

MATERIALS AND METHOD

Crop diversification with resource efficient and remunerative cropping systems is a sustainable agricultural practice. On farm demonstrations with diversified cropping system of soybean + redgram *Vis-a-Vis* farmer’s practice of sole soybean were conducted in Agricultural Research Station, Bidar in ten farmer’s field of Bidar district, Karnataka state during *Kharif* 2020-21 and 2021-22 with an objective to study the production potential of improved cropping system of soybean + redgram (4:1 ratio) intercropping in comparison with farmers practice of sole cropping system. Sowing of crops was done during 2nd week of June month. The observations on seed yield parameters like number of pods per plant, seed yield per plant, seed yield per plot and seed yield per hectare and seed quality parameters *viz.*, physical purity, test weight, germination, seedling length, seedling dry weight and seedling vigour index were recorded and later the data was analyzed to know the beneficial cropping system in terms of seed yield and quality. The data of two years was used for pooled analysis. The statistical analysis and the interpretation of the experimental data was done by using Fischer method of Analysis of Variance technique as outlined by Gomez and Gomez (1984). The level of significance used in F test was 5 per cent for field experiment and 1 per cent for laboratory experiment.

RESULTS AND DISCUSSIONS

A. Yield and yield attributes

The influence of sole and intercrop system on seed yield was found to be significant among the treatments and the data on number of pods per plant and seed yield was presented in Table 1 and 2. From the pooled data of two years, two varieties of soybean grown as sole crop among which the variety V_1: JS-335 showcased significant influence on yield and yield attributing parameters (Fig. 1) which recorded maximum number of pods (22.27), seed yield per plant (11.64 g), seed yield per plot (2.65 kg) and seed yield per ha (21.49 q) as compared to variety V_2: DSb-21 (20.77, 10.68 g, 2.50 kg and 20.25 q) respectively. While in comparison between sole and intercrop, the results of the both treatment was observed to be non significant however numerically, the sole crop of soybean (C_2) recorded maximum number of pods (21.63) and seed yield per plant (11.19 g) compared to intercrop (C_1) (21.40 and 11.14 g). With regarding to seed yield per plot and seed yield per ha there was significant difference was noticed between the treatments in which the sole crop recorded highest seed yield per plot (2.65 kg) and seed yield per ha (21.47 q) when compared with pigeon pea intercropped with soybean in 1:4 ratio in treatment (C_1) (2.50 kg and 20.27 q). Among the interaction between the treatments, there was no significant variation was found. Similar trend was observed in both the years.

The highest or maximum yield recorded in sole cropping in soybean might be due to more availability of all resources like nutrient, moisture and space. Whereas, the slight reduction in yield in intercrop might be due to lower production of photosynthates and more competition for space, nutrients, and soil moisture due to reduced nutritional area per plant. These results are in conformity with the research findings concluded by Ujjinath *et al.* (1990); Goud and Andhalkar (2012); Prakash and Bhushan (2000) also reported that while pigeonpea redgram was intercropped with green gram, gave higher in productivity and profitability in rainfed alfisols.

B. Seed quality parameters

Physical purity. The data recorded on physical purity of soybean influenced by sole and intercropping system in presented in table 3 and it was differed significantly between the treatments in pooled data of two years (Fig. 2). The treatments including the two varieties of soybean grown as sole crop in which the variety V_2: DSb-21 displayed significant difference which recorded highest physical purity (84.58 %) when compared to variety V_1: JS-335 (83.67 %). In second factor between sole (C_2) and intercrop (C_1), highest physical purity was recorded was recorded in sole crop (C_2) (84.78 %) compared to intercrop (C_1) (83.46 %) and in the interaction between the two factors the results was found to be non-significant from pooled data of two years and similar trend was observed in both years.

Test weight. From the pooled data of two years, the test weight was found significant influenced by sole and intercrop treatments and data was presented in table 3 and depicted in Fig. 2. The test weight of the two varieties of soybean grown as sole crop varied significantly in which the variety V_1: JS-335 recorded maximum test weight (12.80 g) as compared to variety V_2: DSb-21 (11.61 g). While in comparison between sole (C_2) and intercrop (C_1), the results of the both treatment was observed to be non significant however numerically, sole crop (C_2) recorded highest test weight (12.26 g) compared to intercrop (C_1) (12.15 g). While in the interaction between the two factors the results was found to be non significant in pooled data analysis and similar trend was observed in 2021 and 2022.

Highest test weight was noticed in sole cropping compared to intercropping. It might be due to proper development of seed and also in accumulation of food reserves like carbohydrates, protein and small amount of lipids in seed during harvest which is directly correlated by 100 seed weight (Anitha *et al*., 2015).

Germination. The data recorded on seed germination as influenced by different treatments of sole and intercrop and their interaction was found to be significant and presented in Table 3. The maximum germination was observed in V_2: DSb-21 (70.93 %) compared to V_1: JS-335 (67.05 %). Between the sole (C_2) and intercrop (C_1) there was no significant variation was observed. However, numerically maximum germination was observed in sole crop (C_2) (69.45 %) compared to intercrop (C_1) of soybean and redgram in 4:1 ratio (68.53 %) while in interaction between two factors the results were found to be non significant from pooled data and similar trend was observed in both years. Among the different treatments, slightly higher seed germination was recorded in sole crop of soybean and the lower seed germination was recorded in soybean + red gram intercropping system (Fig. 2). This was due to fact that no proper development of seeds that results in less accumulation of food reserves and recorded lower seed weight which ultimately might have registered the lower germination (Basave Gowda *et al*., 2020). The similar results were also reported by Mohsen *et al*. (2012) in maize intercropping system.

Seedling length. The observations from the pooled data of two years on seedling length recorded significant variation and was presented in Table 4 and depicted in Fig. 3. The treatments including varieties grown as sole crop in which V_1: JS-335 recorded maximum seedling length (20.93 cm) compared to V_2: DSb-21 (20.23 cm). Whereas, there was no significant variation was noticed between the sole crop and intercrop of pigeon pea and soybean in 1:4 however sole crop (C_2) recorded numerically maximum seedling length (20.61 cm) as compared to intercrop (C_1) (20.23 cm). In interaction between the two factors of varieties and cropping system there was no significant variation in pooled data and similar trend was noticed in 2020 and 2021.

Seedling dry weight. The data on seedling dry weight recorded significant variation and was presented in table 4 and depicted in Fig. 3. From the pooled data of two years, the variety V_1: JS-335 grown as sole crop recorded maximum seedling dry weight (324.40 mg) compared to V_2: DSb-21 (308.40 mg) respectively. Whereas, there was no significant variation was noticed between the sole crop and intercrop of pigeon pea and soybean in 1:4 however sole crop (C_2) recorded numerically maximum seedling dry weight (321.30 mg) as compared to intercrop (C_1) (311.50 mg) respectively. In interaction between the two factors of varieties and cropping system there was no significant variation in pooled data and similar trend was noticed in 2020 and 2021.

Seedling vigour index. The observations from the pooled data of two years on seedling vigour index recorded significant variation and was presented in Table 4 and depicted in Fig. 3. The observation recorded pertaining to seedling vigour index was found to be non-significant between the two varieties grown as sole crop and intercropping of pigeon pea and soybean in 1:4 ratio and the interaction between both the factors didn't differ significantly and similar trend was noticed in both the years.

Table 1: Influence of sole and intercropping system on number of pods per plant and seed yield per plant of soybean (Pooled data of 2020-21 and 2021-22).

Treatments	Number of pods per plant	Seed yield per plant (g)
V_1(JS-335)	22.27	11.64
V_2(DSb-21)	20.77	10.68
SEm±	0.13	0.03
CD @ 5 %	0.55	0.13
C_1(Inter crop)	21.40	11.14
C_2 (Sole)	21.63	11.19
SEm±	0.13	0.03
CD @ 5 %	**NS**	**NS**
V_1C_1	22.14	11.64
V_1C_2	22.39	11.64
V_2C_1	20.66	10.64
V_2C_2	20.87	10.73
SEm±	0.18	0.04
CD @ 5 %	**NS**	**NS**

Table 2: Influence of sole and intercropping system on seed yield per plot and seed yield per hectare of soybean (Pooled data of 2020-21 and 2021-22).

Treatments	Seed yield per plot (kg)	Seed yield per ha (q)
V_1(JS-335)	2.65	21.49
V_2(DSb-21)	2.50	20.25
SEm±	0.01	0.12
CD @ 5 %	0.06	0.51
C_1(Inter crop)	2.50	20.27
C_2 (Sole)	2.65	21.47
SEm±	0.01	0.12
CD @ 5 %	**0.06**	**0.51**
V_1C_1	2.58	20.93
V_1C_2	2.72	22.04
V_2C_1	2.42	19.61
V_2C_2	2.57	20.90
SEm±	0.02	0.17
CD @ 5 %	**NS**	**NS**

Table 3: Influence of sole and intercropping system on physical purity, test weight and germination of soybean (Pooled data of 2020-21 and 2021-22).

Treatments	Physical purity (%)	Test weight (g)	Germination (%)
V_1(JS-335)	83.67	12.80	67.05
V_2(DSb-21)	84.58	11.61	70.93
SEm±	0.11	0.04	0.26
CD @ 5 %	0.48	0.18	1.12
C_1(Inter crop)	83.46	12.15	68.53
C_2 (Sole)	84.78	12.26	69.45
SEm±	0.11	0.04	0.26
CD @ 5 %	**0.48**	**NS**	**NS**
V_1C_1	82.91	12.73	66.65
V_1C_2	84.43	12.87	67.45
V_2C_1	84.02	11.57	70.40
V_2C_2	85.13	11.65	71.45
SEm±	0.16	0.06	0.37
CD @ 5 %	**NS**	**NS**	**NS**

Table 4: Influence of sole and intercropping system on seedling length, seedling dry weight and seedling vigor index of soybean (Pooled data of 2020-21 and 2021-22).

Treatments	Seedling length (cm)	Seedling dry weight (mg)	Seedling vigor index
V_1(JS-335)	20.93	324.40	1403
V_2(DSb-21)	19.91	308.40	1412
SEm±	0.11	3.07	11
CD @ 5 %	0.93	13.25	NS
C_1(Inter crop)	20.23	311.50	1385
C_2 (Sole)	20.61	321.30	1430
SEm±	0.11	3.07	11
CD @ 5 %	**NS**	**NS**	**NS**
V_1C_1	20.77	320.50	1385
V_1C_2	21.08	328.30	1422
V_2C_1	19.68	302.50	1386
V_2C_2	20.13	314.30	1438
SEm±	0.16	4.34	16
CD @ 5 %	**NS**	**NS**	**NS**

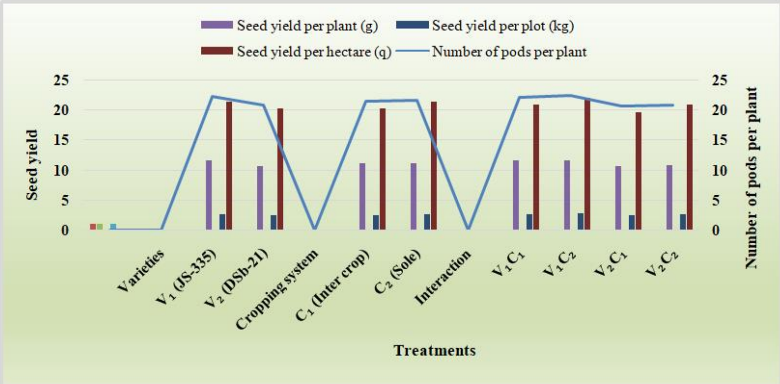

Fig. 1. Influence of sole and intercropping system on number of pods per plant and seed yield of soybean.

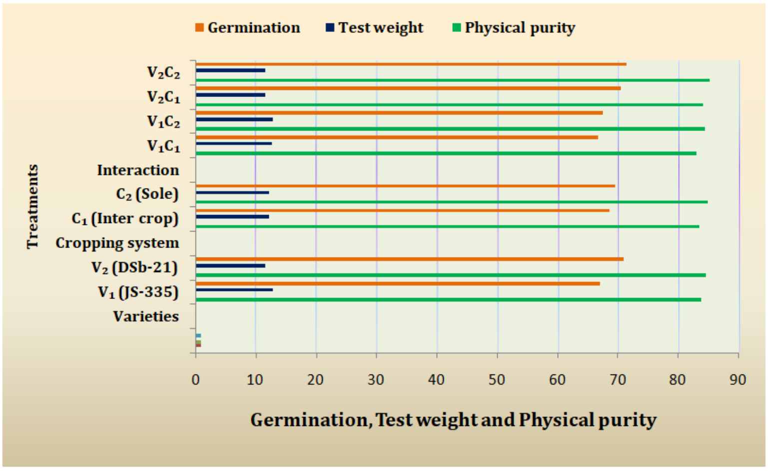

Fig. 2. Influence of sole and intercropping system on germination, test weight and physical purity of soybean.

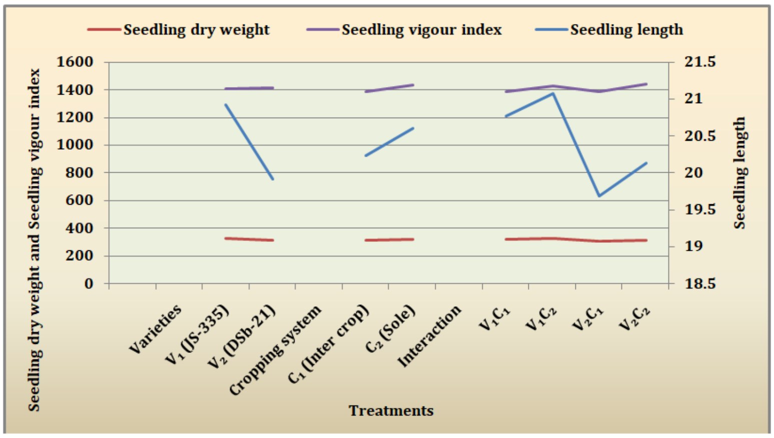

Fig. 3. Influence of sole and intercropping system on seedling length, seedling dry weight and seedling vigour index of soybean.

CONCLUSIONS

From the findings of the experiment studied on influence of sole and intercropping system on seed yield and quality in soybean, it can be concluded that among the two varieties of soybean, the performance of V_1: JS-335 was slightly better than V_2: DSb-21 in seed yield and quality parameters and between sole crop and intercropping the soybean crop performed better as a sole crop but the performance of the crop was on par with redgram intercropped with soybean in 1:4 ratio in terms of the yield and quality parameters. It can be concluded opting for intercropping there will be effective utilization of land and water resource with minimum cost of cultivation and which yield more as compared to sole crop by harvesting two crops from the same piece of land.

REFERENCES

Agegnehu, G., Ghizaw, A. and Sinebo, W. (2006). Yield performance and land-use efficiency of barley and faba bean mixed cropping in Ethiopian highlands. *Eur. J. & Agron.*, *25,* 202–207.

Altieri, M. A., Funes-Monzote, F. R. and Petersen, P. (2012). Agro ecologically efficient agricultural systems for smallholder farmers: Contributions to food sovereignty. *Agron. Sustain. Dev*., *32,* 1–13.

Amanullah, F. K., Muhammad, H., Jan, A. U. and Ali, G. (2016). Land equivalent ratio, growth, and yield components response of mono-cropped vs. inter-cropped common bean and maize with and without compost application. *Agric. Biol. J. N. Am*., 7: 40–49.

Andrews, D. J. (1972). Intercropping with sorghum in Nigeria. *Exp. Agril., 8,* 139-150.

Anitha, M., Swami, D. V. and Suneetha, D. R. (2015). Seed yield and quality of fenugreek cv. Lam methi-2 as influenced by integrated nutrient management. *The Bio Scan*, *10*(1), 103-106

Antle, J. M. and Ray, S. (2020). Sustainable agricultural development an economic perspective. *In Palgrave Studies in Agricultural Economics and Food Policy; Christopher, B., Ed.; Cornell University: Ithaca, NY, USA.*

Basave Gowda, Deepak, T. N., Suma, T. C., Yadahalli, G. S. Sangeeta, I. M. and Prashanth, S. M. (2020). Effect of intercropping and fertilizer dose on seed quality and physiological properties of chickpea (*Cicer arietinum* L.). *Int. J. Curr. Microbiol. App. Sci.*, *9*(1), 591-601.

Baulcombe, D., Crute, I., Davies, B., Dunwell, J., Gale, M., Jones, J., Pretty, J., Sutherland, W. and Toulmin, C. (2009). Reapingthe benefits: Science and the sustainable intensification of global agriculture*; The Royal Society: London, UK.*

Blazewicz-Wozniak, M. and Wach, D. (2011). The Effect of Intercropping on Yielding of Root Vegetables of *Apiaceae* family. *Acta Scientiarum Polonorum-Hortorum Cultus*, *10*(4), 233-243.

Boult, C. and Chancellor, W. (2020). Productivity of Australian broad acre and dairy industries. *Research Report; Australian bureau of agricultural and resource economics and sciences (ABARES): Canberra, Australia.*

Bybee-Finley, K. and Ryan, M. R. (2018). Advancing intercropping research and practices in industrialized agricultural landscapes. *Agriculture*, *8*, 80.

Cowger, C. and Weisz, R. (2008). Winter wheat blends (mixtures) produce a yield advantage in North Carolina. *Agron. J.*, *100,* 169–177.

Dowling, A., Sadras, V. O., Roberts, P., Doolette, A., Zhou, Y. and Denton, M. D. (2021). Legume-oilseed intercropping in mechanized broad acre agriculture–A review. *Field Crops Res*., pp: 260.

Gomez, K. A. and Gomez, Z. A. (1984). Statistical procedures for agricultural research. *A Wiley Inter. Sci. Publication*, New York.

Gou, F., Van Ittersum, M. K., Wang, G., Van der Putten, P. E. and Van der Werf, W. (2016). Yield and yield components of wheat and maize in wheat–maize intercropping in the Netherlands. *Eur. J. Agron*., *76,* 17–27.

Goud, V. V. and Andhalkar, A. S. (2012). Feasibility studies in transplanted pigeon pea + soybean intercropping system. *J. Food Legumes*, *25*(2), 128-130.

Hombegowda, H. C., Adhikary, P. P., Jakhar, P., Madhu, M. and Barman, D. (2020). Hedge row intercropping impact on run-off, soil erosion, carbon sequestration and millet yield. *Nutr. Cycl. Agroecosyst*., *116,* 103–116.

Johnston, G., Vaupel, S., Kegel, F. and Cadet, M. (1995). Crop and farm diversification provide social benefits. *Calif. Agric*., *49,* 10–16.

Kiær, L.P., Skovgaard, I. M. and Østergård, H. (2009). Grain yield increase in cereal variety mixtures: A meta-analysis of field trials. *Field Crops Res*., *114,* 361–373.

Latati, M., Aouiche, A., Tellah, S., Laribi, A., Benlahrech, S., Kaci, G., Ouarem, F. and Ounane, S. M. (2017). Intercropping maize and common bean enhance microbial carbon and nitrogen availability in low phosphorus soil under mediterranean conditions. *Eur. J. Soil Biol*., *80,* 9–18.

Legwaila, G. M., Marokane, T. K. and Mojeremane, W. (2012). Effects of Intercropping on the Performance of Maize and Cowpeas in Botswana. *International Journal of Agriculture and Forestry*, *2*(6), 307-310.

Lin, B. B. (2011). Resilience in agriculture through crop diversification: Adaptive management for environmental change. *BioSci.*, *61*, 183–193.

Ma, Y. H., Fu, S. L., Zhang, X. P., Zhao, K. and Chen, H. Y. (2017). intercropping improves soil nutrient availability, soil enzyme activity and tea quantity and quality. *Appl. Soil Ecol.*, *119,* 171–178.

Makate, C., Wang, R., Makate, M. and Mango, N. (2016). Crop diversification and livelihoods of smallholder farmers in Zimbabwe: Adaptive management for environmental change. *Springer Plus*, *5*, 1135.

Manevski, K., Børgesen, C.D., Andersen, M. N. and Kristensen, I. S. (2015). Reduced nitrogen leaching by intercropping maize with red fescue on sandy soils in North Europe: A combined field and modeling study. *Plant Soil, 388,* 67–85.

Martin-Guay, M. O., Paquette, A., Dupras, J. and Rivest, D. (2018). The new Green Revolution: sustainable intensification of agriculture by intercropping. *Sci. Total Environ.*, *615,* 767–772.

Mohsen, F., Mostafa, A. and Shokouh, D. (2012). Effect of intercropping on vigor of seed corn. *Ann. Bio. Res*., *3*(8), 3962-3967.

Mucheru-Muna, M., Pypers, P., Mugendi, D., Kung'u, J., Mugwe, J., Merckx, R. and Vanlauwe B. (2010). A staggered maize-legume intercrop arrangement robustly increases crop yields and economic returns in the highlands of central Kenya. *Field Crops Res.*, *115,* 132–139.

Nieru, E. M. (2013). Crop diversification: A potential strategy to mitigate food insecurity by smallholders in sub-Saharan Africa. *J. Agric. Food Syst. Community Dev*., *3,* 63–69.

Nyawade, S. O., Karanja, N. N., Gachene, C. K., Gitari, H. I., Schulte-Geldermann, E. and Parker, M. L. (2019). Short-term dynamics of soil organic matter fractions and microbial activity in smallholder potato-legume intercropping systems. *Appl. Soil Ecol*., *142,* 123–135.

Nyawade, S. O., Karanja, N. N., Gachene, C. K., Gitari, H. I., Schulte-Geldermann, E. and Parker, M. (2020). Optimizing soil nitrogen balance in a potato cropping system through legume intercropping. *Nutr. Cycl. Agroecosyst*., *12,* 1–7.

O'Donnell, C. (2018). Productivity and efficiency analysis: An economic approach to measuring and explaining managerial performance, *Springer Nature*, pp: 222.

Prakash, O. M. and Bhushan. L. S. (2000). Productivity and economics of pigeonpea (*Cajanus Cajan*) and castor (*Ricinus communis*) based intercropping systems. *Indian J. of Soil Conservation*, *28*(2), 147-150.

Ren, J., Zhang, L., Duan, Y., Zhang, J., Evers, J. B., Zhang, Y., Su, Z. and Van der Werf, W. (2019). Intercropping potato (*Solanum tuberosum* L.) with hairy vetch (*Vicia villosa*) increases water use efficiency in dry conditions. *Field Crops Res*., *240,* 168–176.

Ren, Y. Y., Wang, X. L., Zhang, S. Q., Palta, J. A. and Chen, Y. L. (2017). Influence of spatial arrangement in maize-soybean intercropping on root growth and water use efficiency. *Plant Soil*, *415,* 131–144.

Schmidt, O., Clements, R. and Donaldson, G. (2003). Why do cereal–legume intercrops support large earthworm populations? *Appl. Soil Ecol*., *22,* 181–190.

Schmidt, O., Curry, J. P. Hackett, R. A., Purvis, G. and Clements, R. O. (2001). Earthworm communities in conventional wheat monocropping and low-input wheat-clover intercropping systems. *Ann. Appl. Biol*., *138,* 377–388.

Sharma, N. K., Singh, R. J., Mandal, D., Kumar, A., Alam, N. M. and Keesstra, S. (2017). Increasing farmer's income and reducing soil erosion using intercropping in rainfed maize-wheat rotation of Himalaya, *Indian Agric. Ecosyst. Environ*., *247,* 43–53.

Sullivan, P. (2003). Intercropping principles and production practices*. Appropriate Technology Transfer for Rural Areas Publication*. pp: 1-3.

Trenbath, B. R. (1993). Intercropping for the management of pests and diseases. *Field Crops Res.*, 34: 381–405.

Ujjinath, U. S., Rajashekar, B. R. Venugopal, N. and Senoappa, K. (1991). Sunflower scheme, University of Agriculture Sciences, GKVK, Bangalore. *J. Oilseeds Res*., *8*, 72-78.

Van Asten, P. J. A., Wairegi, L. W. I., Mukasa, D. and Uringi, N. O. (2011). Agronomic and economic benefits of coffee–banana intercropping in Uganda's smallholder farming systems. *Agric. Sys.*, *104,* 326–334.

Yu, Y., Stomph. T. J., Makowski, D, and Van der Werf, W. (2015). Temporal niche differentiation increases the land equivalent ratio of annual intercrops: a meta-analysis. *Field Crops Res.*, *184,* 133–144.

Zhang, C., Dong, Y., Tang, L., Zheng, Y., Makowski, D., Yu, Y. Zhang, F. and Van der Werf, W. (2019). Intercropping cereals with faba bean reduces plant disease incidence regardless of fertilizer input; a meta-analysis. *Eur. J. Plant Pathol*., *154,* 931–942.

Zhu, Y., Chen, H., Fan, J., Wang, Y., Li. Y., Chen, J., Fan. J., Yang, S., Hu. L., Leung, H., Mew, T. W., Teng, P. S., Wang. Z. and Mundt, C. C. (2000). Genetic diversity and disease control in rice. *Nature*, *406,* 718–722.

How to cite this article: Gnyandev B., Umesh Hiremath, Shivakumar B. Bagli, Basave Gowda, Sunilkumar N.M. and Ningdalli Mallikarjun (2023). Influence of Sole and Intercropping System on Seed Yield and Quality in Soybean. *Biological Forum – An International Journal, 15*(10): 1310-1316.