Annals of Agri-Bio Research **28** (2): 406-412, 2023 **Impact Score : 0.28 (Scopus)**

Effect of Legume based Intercropping System on Growth, Yield and Yield Assessment Studies in Maize (*Zea mays*)

MULINITI SOWJANYA, DEEKSHITH REDDY, ANITA JASWAL* AND ARSHDEEP SINGH

Department of Agronomy, School of Agriculture, Lovely Professional University, Phagwara-144 411 (Punjab), India

**(e-mail: anita.27139@lpu.co.in, Mobile: 95017 03516)*

(Received: March 15, 2023; Accepted: April 21, 2023)

ABSTRACT

The field experiment was conducted in Agriculture Research Farm of Lovely Professional University, Phagwara, during *kharif* season of 2022. The experiment was laid out in randomized block design with seven treatments and three replications. The treatments included T_1–Sole maize, T_2–Sole moongbean, T_3–Sole soybean, T_4–Maize+moongbean 1:2, T_5–Maize+soybean 1:2, T_6–Maize+moongbean 1:3 and T_7–Maize+soybean 1:3. Plant height (196.0 cm), stem girth (9.3 cm), number of leaves/plant (15.7), leaf area (1052.2 cm^2), chlorophyll index (41.2 SPAD), crop growth rate (2.53 $g/m^2/day$) and relative growth rate (0.490 gg/day) were recorded highest under maize+moongbean (1:3). Similarly, grain yield (5882.0 kg/ha), seed index (386.5 g), cobs/plant (1.8), cob length (19.3 cm), cob diameter (8.5 cm), number of grains/cob (17.67), straw yield (7519.0 kg/ha) and harvest index (43.86%) were also recorded maximum with maize+moongbean (1:3) which was significantly better to all the treatments. The yield assessment functions like land equivalent ratio (LER) and maize equivalent yield (MEY) prominently indicated the benefits of maize-legume intercropping system under Punjab region.

Key words: Legume, intercropping, zero hunger, yield assessment, sustainability

INTRODUCTION

Maize (*Zea mays*) is one of the important coarse cereal crops belonging to Poaceae family. It is called as "Queen of cereals" because of its high genetic potential among cereal crops. Maize adapts to a wide range of agro-climatic conditions. Maize is the 3rd most eminent crop in India, following rice and wheat. According to second advance estimate of 2020-21, maize is cultivated on 9.38 m ha with a production of 30.16 mt (Government of India, 2020). India ranks 4th in terms of area and 7th in terms of production among maize growing countries, accounting for approximately 4 and 2% of global maize area and production, respectively (Sagar *et al.,* 2020). Legumes are widely grown all over the world, and their nutritional and economic significance is understood and recognized on a global scale.

For majority of human population, legumes not only provide more variations in the diet but also act as an affordable source of supplemental proteins. Therefore, legumes are said to be poor man's food. Maize has been recognized as a common component in most intercropping system and it seems to lead as the cereal constituent of intercrop and is regularly combined with dissimilar legumes. Intercropping is growing of two or more generally dissimilar crops simultaneously on the same piece of land with distinct row arrangement. The main reason to adopt intercropping is to increase productivity per unit area per unit time by efficiently utilizing the resources (Manasa *et al., 2*020). Biological efficiency of intercropping gets improved due to exploration of large soil mass compared to mono-cropping. Moreover, by adoption of inter cropping risks in crop cultivation can be minimized and the natural resources are fully utilized. One of the most promising approaches in India is intercropping legumes with cereals, which has been acknowledged as a frequent practice to increase the variety of environmentally friendly agricultural production methods (Shah *et al.,* 2019). The only method that appears to boost production and land use intensity is through intercropping. Studies on intercropping have shown how niche variations in crop species can facilitate resource collection and resource conversion, increasing biological efficiency and yield. The essential agronomic technique of cereal-legume intercropping typically results in a system that is more efficient than that of each component (Tripathi *et al.,* 2019). Resources could be improved by interplanting grains like maize (*Zea mays*) with legumes (green and black gram) for light, moisture, mineral nutrients, etc. Because of the combined use of inputs in respect to time and space, the use of intercropping is promoted as a fresh and enhanced method of farming. Because the component crops make the best use of the available resources, an effective intercropping yield more than a sole cropping complement one another (Pierre *et al.*, 2022). The yield advantages of an intercropping system are primarily due to the different use of growth resources by component crops, when the growth patterns of the component crops differ in time, complementarily occurs (Ananthi *et al.,* 2017). The system not only serves as crop insurance, but it also helps to reduce soil erosion if the plants of subsidiary crops trail. Crop rotation can also be accomplished through proper intercropping (Patel *et al.,* 2018). Using proper intercropping techniques and patterns crops with superior yield stability, productivity per unit area could be boosted (Zhang *et al.,* 2021). The cultivation of soybean (*Glycine max*) and greengram (*Vigna radiata*) has expanded due to their broad household and industrial uses, importance for human nutrition and economic value. When planning intercrops spatial arrangements of plant, planting rates and maturity dates must be considered (Madembo *et al.,*2020). The choice of legume species, seeding ratio or row proportion and competition ability within mixtures may affect the growth of the species used in intercropping systems. The impact of maize-based cropping system was not much studied. As a result, the study was carried out to assess the efficiency of the maize-legume intercropping system with respect to yield advantage.

MATERIALS AND METHODS

During the *kharif* season of 2022, a field experiment named 'Effect of Legume-based Intercropping System on Growth, Yield and Yield Assessment Studies of Maize' was carried out. at Agricultural Research Farm of Lovely Professional University, Phagwara having 31°N, 31.25°N Latitude 75°E. The site enjoyed subtropical climate with hot and humid summers and severe cold winters during the period of experimentation. The experiment was laid out in a randomized block design with three replications and seven treatments. The treatments included sole maize, sole greengram and sole soybean, maize+ greengram (1:2), maize+green gram (1:3), maize+soybean (1:2) and maize+soybean (1:3). TA 5084 variety of maize, SML 688 variety of green gram and Himsoya variety of soybean were used in the experiment. Fertilizers were applied proportionate to the sole optimum population for main and intercrop separately in intercropping treatments. Prior to starting the experiment, four randomly chosen places from the experimental field were sampled at depths of 0-15 and 15-30 cm, to create a composite sample. The soil at experimental site was sandy loamy texture basic in reaction with pH of 7.5 having organic carbon content, nitrogen, phosphorus and potassium as 13.2 mg/kg, 96.9 mg/kg, 5.2 mg/kg and 105.3 mg/kg, respectively. Sowing of hybrid maize was done at a spacing of 60 x 20 cm. Pure stand of legume i.e. greengram and soybean was sown at 30 x 10 and 30 x 5 cm spacings. As per the treatments, single and double row of intercrops were taken in between pairs of maize.

The fertilizer doses for hybrid maize and grain legumes were 120 kg N, 60 kg P_2O_5 and 60 kg K_2O/ha and 20 kg N, 40 kg P_2O_5 and 20 kg K_2O/ha, respectively. The sources of N, P_2O_5 and K_2O were urea, single super phosphate and muriate of potash, respectively. In case of sole cropping of legumes, the entire fertilizers were applied as basal. However, in maize half of N and full dose of P_2O_5 and K_2O were applied as basal and remaining 50% of N fertilizer was applied at knee high stage. In maize and legume intercropped plots, the fertilizer dose were applied as per recommendation for maize. All the agronomic and cultural practices were followed for main crop as well as for intercrop as per PAU package of practices.

Growth and yield parameters were recorded as per standard procedures and analyzed statistically. Leaf area (cm^2) was measured by leaf area meter and chlorophyll index was measured by SPAD meter. Growth analysis (CGR, RGR) was calculated. Land equivalent ratio was calculated as:

$$LER = \frac{Yab}{Yaa} + \frac{Yba}{Ybb}$$

Where: Yab = Intercropped yield of crop a, Yba = Intercropped yield of crop b, Yaa = Sole crop yield of crop a and Ybb = Sole crop yield of crop b.
Maize equivalent yield was calculated as:

$$MEY = \frac{\text{Grain yield of intercrop}}{\text{Market price of maize}} \times \text{Market price of inter crop}$$

ANOVA was carried out using SPSS 22 software. Homogeneity of variance was estimated, and results were expressed as means±standard deviation. To find out the most efficient treatment, Duncan's multiple range test (DMRT) was applied at P< 0.05.

RESULTS AND DISCUSSION

Highest plant height of 196.0 cm was recorded under maize+moongbean (1:3) intercropping system. Second highest plant height 192.2 cm was recorded in maize+soybean (1:3). T_6 (maize+greengram 1:3) and T_7 (maize+soyabean 1:3) were statistically non-significant among themselves. Lowest plant height of 177.3 cm was recorded in T_1 (sole maize) which was followed by T_4 (maize+moongbean 1:2). Nutrient availability as well as without any weed stress by the presence of intercrops might have resulted higher cell division and elongation. Similar findings were recorded by Manasa *et al.* (2020). Stem girth in maize + moongbean 1:3 was highest 9.3 cm compared to all the intercrops and sole maize. Second highest stem girth of 8.9 cm was recorded in T_5 (maize+soyabean 1:2). T_1 (sole maize) showed the lowest stem girth 8.0 cm. Number of leaves was more (15.7) in maize+green gram 1:3. Second highest number of leaves (14.3) was observed in maize+soybean 1:3 which was statistically at par with T_6 (maize+moongbean 1:3). Lowest number of leaves was recorded in T_1 (sole maize) which was followed by T_4 (maize+moongbean). Due to less insect and pest attack, the number of leaves was more in intercropping of maize with legumes compared to sole maize. Highest dry weight 223.2 g was recorded in maize+moongbean 1:3 followed by maize+soybean 1:3. Lowest dry matter accumulation 208.3 g was seen in sole maize. Maximum dry matter accumulation was recorded in intercropping might be due to availability of nutrient which was enhanced due to biological nitrogen fixation by moongbean associated to higher photosynthetic production and accumulation. The dry matter production was mainly influenced by assimilatory surface area and its photosynthetic activity. Similar findings were reported by Sannagoudar *et al.* (2021). Intercropping exerted higher chlorophyll index (41.20 SPAD) in maize+moongbean 1:3 and second highest chlorophyll index (39.20 SPAD) in maize+soybean 1:3. T_7 and T_5 were non-significant among themselves and were statistically at par with T_4. Lowest chlorophyll content 35.25 SPAD was recorded in sole maize. It was as more atmospheric nitrogen as fixed by legumes in intercropping maize than sole maize. Highest leaf area 1052.0 cm^2 was recorded in maize + moongbean 1:3 with second highest leaf area 1047.0 cm^2 in maize+soybean 1:3. Maize+moongbean 1:2 as 1022.5 cm^2, and maize+soybean 1:2 with 1026.6 cm^2 are non- significant (Table 1). The lowest leaf area (1005.9 cm^2) was observed in sole maize. Higher leaf area/plant may be attributed to a greater number of leaves produced due to more nutrient availability in the presence of legume components in the system which contributed through biological nitrogen fixation and weed smothering effect. While the lower leaf area/plant was observed mainly due to suboptimal utilization and availability of nutrients and space by the component crops. The results are in conformity with the observation made by Sannagoudar *et al.* (2021) in maize based cropping system. Maize showed greater CGR of 2.53 $g/m^2/day$ in maize+moongbean 1:3 intercropping as compared to sole cropping which recorded lowest CGR value of (2.13 $g\ m^2/day$). It might have resulted in reduced growth and lesser leaf area development as observed in the studies conducted by Sannagoudar *et al.* (2021). Second highest CGR 2.40 $g/m^2/day$ was recorded with maize+soybean 1:2. The RGR of intercropping maize+soybean 1:3 was 0.503 g/g/day greater as compared to mono-cropping (sole maize). More CGR and RGR recorded in intercropping might be due to increased primary branches with more leaves and leaf area index which could increase nitrogen supply by legume.
The economic yield of any crop is an outcome of several integrated physiological and biochemical processes taken place during growth and development of plant in accordance

Table 1. Effect of legume-based intercropping on maize growth parameters

Treatment	Plant height (cm)	Stem grith (cm)	No. of leaves	Dry weight (g)	Chlorophyll index (SPAD)	Leaf area (cm^2)	CGR ($g/m^2/day$)	RGR (gg/day)
T_1–Sole maize	$177.3^{c}\pm1.16$	$8.0^{c}\pm0.1$	$13.3^{d}\pm0.34$	$208.3^{d}\pm1.7$	$35.25^{d}\pm1.7$	$1005.1^{d}\pm2.5$	$2.13^{d}\pm0.11$	$0.491^{ab}\pm0.0068$
T_4–Maize+mungbean (1:2)	$180.67^{bc}\pm1.25$	$8.7^{b}\pm0.2$	$13.4^{cd}\pm0.31$	$220.3^{bc}\pm1.5$	$37.4^{bc}\pm0.6$	$1022.5^{bc}\pm1.8$	$2.26^{bc}\pm0.02$	$0.459^{ab}\pm0.0142$
T_5–Maize+soyabean (1:2)	$183.00^{b}\pm3.27$	$8.9^{b}\pm0.1$	$14.0^{bc}\pm0.21$	$216.9^{c}\pm2.4$	$38.37^{ab}\pm0.7$	$1026.6^{b}\pm1.2$	$2.40^{b}\pm0.10$	$0.449^{b}\pm0.0250$
T_6–Maize+mungbean (1:3)	$196.00^{a}\pm1.23$	$9.3^{a}\pm0.2$	$15.7^{a}\pm0.25$	$235.4^{a}\pm2.5$	$41.20^{a}\pm0.8$	$1052.2^{a}\pm2.9$	$2.53^{a}\pm0.03$	$0.490^{ab}\pm0.0189$
T_7–Maize+soyabean (1:3)	$192.20^{a}\pm2.44$	$8.9^{b}\pm0.1$	$14.3^{b}\pm0.21$	$223.2^{b}\pm1.5$	$39.20^{ab}\pm1.9$	$1047.0^{bc}\pm1.7$	$2.30^{bc}\pm0.09$	$0.503^{a}\pm0.0206$

Different subscripts differ significantly.

with the supply of light, temperature, water and nutrients. Lowest seed index was recorded with maize+moongbean 1:2 which was statistically at par with maize+soybean 1:2 (Table 2). Highest seed index in maize+moongbean indicated the great utilization of available nutrients in legume intercropping than sole maize. Highest cob length was recorded in maize+moongbean 19.3 cm followed by maize+soybean 1:3 (18.5 cm) followed by maize+soybean 1:2 (17.3 cm) which are statistically at par with maize+moongbean 1:2. However, the lowest cob length was noticed in sole maize. Cob diameter was higher in maize+moongbean 1:3 though non-significant to maize+soybean 1:3 (8.5 cm) followed by maize+moongbean 1:2 and maize+soybean 1:2 (7.8 cm) which are non-significant to each other, lowest cob diameter in sole maize was possibly due to heavy weed infestation. Greater diameter in maize+moongbean 1:3 was likely a cause to an increase in number of rows in intercrops that showed non-significant effect on intercrops compared to sole cropping which recorded lowest cob diameter. More number of grains was observed in maize+greengram 1:3 (480.5) and maize+soybean 1:3 (484.3) which were non-significant to each other. Second highest was recorded in maize+soybean (475.7) followed by maize+soybean (1:2). The higher values with respect to yield attributing character were attributed to higher light absorption and enhanced nutrient availability resulting in better utilization of solar energy and nutrients, resulting in higher dry matter accumulation and better translocation of photosynthates from source to sink. Similar findings were also observed by Manjangouda *et al.* (2018). Highest grain yield was recorded in maize+moongbean 1:3 (561.8 kg/ha) as synergistic effect of maize in association with moong bean in high density paired row pattern was greater. Second highest was noticed in maize+soybean 1:3 (5794.0 kg/ha) and low grain yield in sole maize. Straw yield of maize was highest in maize+moongbean 1:3 (7519 kg/ha) compared to sole crop and intercrops. The data related to the harvest index of maize in different treatments showed non-significant effect between treatments. Since, the economic yield is a part of total biological yield, accumulation of total dry matter with better growth and development of crop helped in enhancement of economical yield of crop.

Table 2. Effect of intercropping on maize yield attributes and yield

Treatment	Seed index (g)	Cobs/plant	Cob length (cm)	Cob diameter (cm)	No. of rows/ cob	No. of grains cob	Grain yield (kg/ha)	Straw yield (kg/ha)	H.I. (%)
T_1–Sole maize	320.9^{a}±3.9	1.17^{c}±0.24	16.7^{d}±0.12	7.4^{c}±0.2	14.33^{d}±0.47	458.0^{c}±1.6	5611.8^{d}±4.40	7155.67^{e}±22.94	43.89^{b}±0.16
T_4–Maize+mungbean (1:2)	339.0^{bc}±11.5	1.3^{b}±0.47	17.3^{cd}±0.16	7.8^{b}±0.1	15.33^{bc}±0.47	462.1^{c}±1.6	5722.6^{c}±8.73	7324.67^{c}±22.60	44.32^{a}±0.07
T_5–Maize+soyabean (1:2)	347.7^{b}±15.1	1.3^{b}±0.47	17.7^{c}±0.45	7.8^{b}±0.1	15.67^{b}±0.47	475.7^{b}±3.3	5724.9^{c}±11.73	7232.3^{d}±15.52	43.76^{b}±0.082
T_6–Maize+mungbean (1:3)	386.5^{a}±13.4	1.83^{a}0.24	19.3^{a}±0.39	8.5^{a}±0.3	17.67^{a}±0.47	484.3^{a}±1.7	5882.0^{a}±5.72	7519.0^{a}±43.23	43.86^{b}±0.074
T_7–Maize+Soyabean (1:3)	384.0^{a}±7.9	1.67^{b}±0.42	18.5^{b}±0.19	8.2^{a}±0.1	16.33^{b}±0.47	480.5^{a}±1.5	5794.0^{b}±4.32	7414.67^{b}±17.00	43.86^{b}±0.091

Different subscripts differ significantly.

Assessment of maize yield in different treatments indicated that significantly higher kernel and stover yield was observed with introduction of legume intercrops which enhanced nutrient supply through biological nitrogen fixation and enhanced rhizosphere activity in cereal legume association meeting the microclimate requirement of the crop which could be related to improved growth parameters. The results are in accordance with the findings of Sagar *et al.* (2020).

Number of pods in legumes was more in maize+soybean 1:3 (78.5/plant) and sole soybean (77.2), whereas both were statistically non-significant among themselves followed by maize+moongbean 1:3 (13.57). Maize with soybean 1:3 intercropping system produced a greater number of seeds/pod (Table 3). Test weight of pulses was highest in maize+moongbean 1:3 (39.63 g) which was statistically at par with sole moongbean. Highest pod yield was highest in sole soybean (914.7 kg/ha). Zhang *et al.* (2021) reported that the yield of all the intercrops with maize decreased compared with their sole crop. The results are in confirmation with the studies of Madembo *et al.* (2020) Manasa (2018) under maize-based cropping systems. Intercropping resulted in increased competition for soil moisture and nutrients as well as atmospheric factors like light and this competition restricted the development of the plant as whole in intercropping system.

All intercropping treatments recorded higher maize equivalent yield and LER than sole maize crop. Significantly higher maize equivalent yield (11.34 t/ha) was observed in maize+soybean 1:3 followed by maize+moongbean 1:3 (10.34 t/ha). Higher LER (1.99) was observed in maize+moongbean 1:3 intercropping, and it was closely followed by maize+soybean 1:3 with 1.87 (Table 3). Assessment of maize equivalent yield in different treatments indicated that significantly higher kernel and stover yield was observed with maize and legume intercrops which could be attributed to higher yield obtained by legume cereal association and the additional yield of intercrops than the sole maize alone. Further, the market price of maize and intercrops also influenced the equivalent yield. However, enhanced growth and yield attributes contributed much on the yield of maize as well as intercrops. The results

Table 3. Effect of intercropping on yield parameters of pulses and yield assessment studies

Treatment	Number of pods/ plant	Seeds/pod	Test weight (g)	Pod yield (kg/ha)	LER	MEY (t/ha)
T_1–Sole maize	-	-	-	-	1.0±0.00	5.88[e]±5.715
T_2–Sole moong bean	18.57[c]±0.49	11.77[b]±0.565	38.67[ab]±0.68	815.4[b]±2.18	1.0±0.00	-
T_3–Sole soybean	77.23[a]±0.61	2.26[d]±0.206	31.17[c]±0.46	914.7[a]±3.20	1.0±0.00	-
T_4–Maize+mungbean (1:2)	16.37[d]±0.33	12.5[b]±0.408	38.0[b]±0.41	633.23[d]±4.45	1.75[c]±0.00	9.09[d]±17.240
T_5–Maize+soyabean (1:2)	73.97[b]±1.19	2.23[d]±0.205	31.13[c]±0.33	693.90[c]±4.20	1.72[d]±0.006	10.38[b]±25.409
T_6–Maize+mungbean (1:3)	19.00[c]±0.41	13.57[a]±0.330	39.63[a]±0.90	810.97[b]±6.60	1.99[a]±0.013	10.17[c]±39.139
T_7–Maize+soyabean (1:3)	78.5[a]±0.41	3.1[c]±0.099	30.83[c]±0.53	819.33[b]±3.01	1.87[b]±0.011	11.34[a]±28.323

are like the findings of Bekele *et al.* (2021). Similar findings were reported by Manjangouda *et al.* (2018) in maize-based intercropping system. The difference in MEY was mainly because of differences in the yield of maize, crop yield and price of individual component crops.

CONCLUSION AND FUTURE THRUST

The results of this study clearly showed the significant impact of different row proportions of legumes intercropped with maize on growth and yield. Maize+moongbean 1:3 ratio had shown the best results over all the treatments with good yield and higher monetary returns. Use of legumes in maize-based intercropping can also curtail the use of inorganic nutrients and larger requirements of nutrient may be fulfilled through biological N fixation. Further studies are needed to determine long term benefits in terms of yield advantage and soil fertility improvement under maize-based intercropping.

ACKNOWLEDGEMENT

The authors express their bottomless gratitude to Lovely Professional University, Jalandhar, Punjab (India) for providing a well-equipped research farm and laboratory to conduct research and biochemical analysis in the present work.

REFERENCES

Ananthi, T., Amanullah, M. M. and Al-Tawaha, A. R. M. S. (2017). A review on maize-legume intercropping for enhancing the productivity and soil fertility for sustainable agriculture in India. *Adv. Environ. Biol.* **11**: 49-64.

Bekele, B., Ademe, D., Gemi, Y. and Habtemariam, T. (2021). Evaluation of intercropping legume covers with maize on soil moisture improvement in misrakazerinetberb-ereworeda, Ethiopia. *Water Cons. Sci. Eng.* **6**: 145-151. *https://doi.org/10.1007/s41101-021-00109-w.*

Madembo, C., Mhlanga, B. and Thierfelder, C. (2020). Productivity or stability? Exploring maize-legume intercropping strategies for small holder conservation agriculture farmers in Zimbabwe. *Agric. Syst.* **185**: *102921.https://doi.org/10.1016/j.agsy.2020.102921.*

Sagar Maitra, Shankar, Tanmoy and Banerjee, Pradipta (2020). Potential and advantages of maize-legume intercropping system. *Maize Prod. Use* **2020**: 01-14.

Manasa, P., Maitra, S. and Barman, S. (2020). Yield attributes, yield, competitive ability, and economics of summer maize-legume intercropping system. *Int. J. Agric. Environ. Biotech.* **13**: 33-38. *http://dx.doi.org/10.30954/0974-1712.1.2020.16.*

Manasa, P., Maitra, S. and Reddy, M. D. (2018). Effect of summer maize-legume intercropping system on growth, productivity and competitive ability of crops. *Int. J. Manag. Technol. Eng.* **8**: 2871-2875.

Patel, A. K., Ardeshna, R. B., Kumarm, D. and Mawalia, A. K. (2018). Growth and yield of summer maize as influenced by intercropping systems. *J. Pharm. Phytochem.* **7**: 1004-1007.

Pierre, J. F., Latournerie-Moreno, L., Garruña, R., Jacobsen, K. L., Laboski, C. A., Us-Santamaría, R. and Ruiz-Sánchez, E. (2022). Effect of maize-legume intercropping on maize physio-agronomic parameters and beneficial insect abundance. *Sustainability* **14**: 12385. *https://doi.org/10.3390/su141912385.*

Pierre, J. F., Latournerie-Moreno, L., Garruña-Hernández, R., Jacobsen, K. L., Guevara-Hernández, F., Laboski, C. A. and Ruiz-Sánchez, E. (2022). Maize-legume intercropping systems in southern Mexico: A review of benefits and challenges. *Ciência Rural* **52**. *https://doi.org/10.1590/0103-8478cr20210409.*

Sannagoudar, M. S., Murthy, K. K., Ghosh, A., Singh, A. K., Gupta, G., Halli, H. M. and Kumar, R. V. (2021). Comparative efficacy of leguminous intercrops and weed management practices on nutrient uptake, productivity and profitability of maize based intercropping system. *Legume Res. Int. J.* **44**. *doi:10.18805/LR-4743.*

Sannagoudar, M. S., Murthy, K. N. K., Nagaraju, Rajanna, G. A., Ghosh, A., Singh, A. K., Gupta, G. and Kumar, R. V. (2021). Influence of weed management practices in maize (*Zea mays*)-based intercropping system. *Indian J. Agric. Sci.* **91**: 1067-1071.

Tripathi, P., Shah, S., Kashyap, S. D. and Tripathi, A. (2019). Fruit yield and quality characteristics of high-density Prunus persica (L.) Batsch plantation intercropped with medicinal and aromatic plants in the Indian Western Himalayas. *Agroforestry Systems* **93**: 1717-1728. *https://doi.org/10.1007/s10457-018-0276-9.*

Zhang, W. P., Gao, S. N., Li, Z. X., Xu, H. S., Yang, H., Yang, X. and Li, L. (2021). Shifts from complementarity to selection effects maintain high productivity in maize-legume intercropping systems. *J. Appl. Eco.* **58**: 2603-2613. *doi: 10.1111/1365-2664.13989.*