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ASSESSMENT OF CEREAL AND LEGUME BASED INTERCROPPING ON PRODUCTIVITY AND PROFITABILITY OF QUALITY FODDER PRODUCTION : A REVIEW

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SUMMARY

Cereal and legume based intercropping in fodder play an important role for providing a balanced diet to the livestock. The inclusion of legumes into cereal fodders has potential to enrich the fodder quality without compromising the quantity. However, it increases the total quantitative fodder production. Per capita land availability has been decreasing over the years and also, huge competition among the food crops created a tremendous pressure on the available land. In order to increase productivity per unit area, there is a need to evaluate the promising forage species having high forage yield potential and quality as well as compatibility for intercropping. The present review summarizes the benefits of intercropping on fodder yield and quality. Furthermore, it discusses the influence of intercropping on soil nutrient status, uptake and profitability, which has been revealed and cited by different scientists and researchers.

Key words : Cereal, legume, fodder, intercropping and quality

Livestock is the wealth and power across civilization. This sector stands as a boon to the rural economy by contributing 25.6% of total agricultural GDP (Gross Domestic Product). India stands first in cattle population and milk production across the globe, but milk production per lactation is less as compared to developed countries (1310 kg per lactation) (Hegde, 2019). Low milk production is due to insufficient and poor quality fodder. Most of the time, farmers rely on crop residues after harvest as fodder, which is low in nutrition and high in lignin content leads to low milk production. Furthermore, the substitution of desi cows by exotic breeds having high milk yielding potential demands huge nutrition for high milk yield, which has created mineral deficiency in dairy animals due to non-fulfillment of the nutritional demand has decreased the milk production. Most of our farmers grow cereal and legume fodder separately and feed them to cattle based on their availability leads to an imbalanced diet. This problem can be overcome by the inclusion of legumes with grasses, in turn helps to supply minerals, as legumes are rich source of crude protein, calcium, phosphorous, iron, *etc*. The inclusion of legumes into cereal fodders helps in the enrichment of fodder quality by decreasing crude fibre content along with the enhancement of crude protein as fodder cereals are low in protein content (Ibram *et al*., 2006). Studies have reported that intercropping of legumes with fodder cereals supplemented the protein requirements by increasing the forage intake and digestibility (Javamard *et al*., 2009). Additionally, intercropping of legumes with cereal fodders supplied balanced minerals to the dairy animals, as legume fodder is superior in the accumulation of minerals such as calcium, magnesium, copper, zinc, manganese, and cobalt *etc*. in comparison to cereal fodder (Juknevicius and Sabiene, 2007). It also contributed in reducing feed costs (about 30-40%) by supplying enriched nutritive fodder to livestock (Manpreet and Naveen, 2020). Legumes have the ability to supply nitrogen to the main crop by symbiotic nitrogen (N) fixation through their nodules. Besides, it also helps in solubilizing the unavailable phosphorous (P) into an available form in the soil, controlling weeds, increasing soil microbial activity, and supplying nutrients to the succeeding crop apart from meeting the requirements of existing crops (Ghosh *et al*., 2007). A systematic

review of cereal and legume based fodder intercropping impact on growth, productivity, fodder quality, soil quality, and profitability has been cited on the basis of findings and views of active investigators, theoreticians, and practitioners are discussed under the following headings.

Growth and development of fodder crops as influenced by intercropping

Several research findings reported that there is a significant variation in growth attributes when cereal fodders are intercropped with a legume in terms of height, number of leaves, and dry matter production as compared to the sole crop. Ayub *et al*. (2004) reported significant variation in growth of sorghum when sown with different seed proportions of ricebean. This investigation revealed maximum height of sorghum in 100:0 (sorghum: ricebean) proportion which was statistically at par to 75:25 proportion. Further increase in ricebean seed rate decreased the sorghum plant height and there was no significant impact observed on ricebean height. Similar findings were observed by Rundan *et al*. (2021) at National Dairy Research Institute, Karnal in fodder maize and ricebean intercropping and reported that growth parameters *viz*., plant height, number of leaves and leaf area of maize were significantly higher in sole maize compared to other intercropped treatments. Whereas, ricebean recorded superior plant height under intercropped condition and rest of the growth attributes were superior under sole treatment. Maximum growth under sole crop might be due to higher uptake of nutrients along with good light interception which increased meristematic activity and photosynthesis of plant in turn increases inter-nodal length of sole maize. Further, ricebean height was more in intercropped condition because of physical support from maize to trail and competition from maize for light increased the auxin content in ricebean meristem as shade promotes elongation of internodes. From the intercropping of maize and cowpea with different seed ratios, it was observed that the highest plant height of maize (227.8 cm), number of leaves (12.8 per plant) were observed in sole maize and same trend was observed in cowpea with highest height (202.7cm) and number of leaves (55.95 per plant) in comparison with 50:50, 65:35, 35:65, 75:25 and 25:75 seed ratios, respectively (Ibrahim *et al*., 2006).

Nadeem *et al.* (2009) observed linear increase in plant height, number of leaves, leaf area and stem diameter of maize from maize and legume combinations by increasing dose of nitrogen up to 150 kg/ha with obtaining highest dry matter by sowing maize and sesbania (legume) in combination. From various intercropping systems at Nigeria, sole mungbean recorded highest number of nodules (17.7 per plant), plant height (20.7) and number of leaves (16.7 per plant) which was statistically on par with melon and mungbean intercropping and significantly differ with maize and mungbean intercropping system (Onuh *et al.,* 2011). The study on intercropping of maize with various legumes from Andhra Pradesh revealed maximum dry matter accumulation from maize and cowpea intercropping (9205 kg/ha) and lower from sole pillipesara (Prasanthi, 2012). Dhara *et al.* (2013) observed similar findings in maize and pea intercropping system in which higher dry matter accumulation was observed in sole maize system and lower in 2:1 ratio of maize and pea intercropping and this might be due to competition between maize and pea for available resource but highest land equivalent ratio was noticed in 2:1 ratio intercropping of maize and pea. In maize and bean intercropping, dry matter accumulation of maize decreased as compared to sole maize since the additional of beans population has created competition for available resources, but total dry matter accumulation was higher in intercropped treatments compare to sole maize (Morgado and Willey, 2013). In Nigeria, there was no significant difference observed in different growth parameters such as plant height, number of leaves and branches in sole and intercropped cowpea with maize. However, higher stover yield was observed by sowing maize and cowpea in the ratio of 1:1 in comparison with 2:1 and 1:2 ratios (Iderawumi, 2014). Yavas and Unay (2016) from Turkey revealed that higher LAI, LAR and NAR were observed by planting maize with soybean or cowpea in alternative rows as compared to sole crop. They have also reported that greater NAR was observed during reproductive stage and LAI, LAR and RGR were greater during vegetative stage of crop. Higher plant height (208.8 cm) and dry matter per plant (211.1 g) were observed in maize combination with mungbean as compared to sole maize (Yadav *et al*., 2016). By sowing maize and various legumes in the ratio of 1:1 recorded higher growth attributes in maize namely plant height, number of leaves, stem girth, leaf length, leaf width, and leaf stem ratio in comparison with rest of the ratios (Ginwal *et al*., 2019).

The citied research reports revealed that growth of fodder cereals was not affected by legume intercropping up to certain extent, but beyond the elasticity limit of cereals, there was a decrease in

growth observed with increase in intercrop proportions. This might be due to the competition between component crops for available resource that led to decrease in photosynthetic area and dry matter accumulation of individual crop.

Fodder productivity as influenced by intercropping

Intercropping seems to have advantages under rainfed conditions as it provides additional intercrop yield along with main crop in good rainy seasons and reasonable yield even in low rainfall areas due to different plant and root morphology of cereal and legume fodder. Intercropping of maize with ricebean decreases the individual yield of both crops, but higher yield was obtained by growing both the crops in combination (Zaman and Malik, 2000). This may be due to inter competition between maize and ricebean for available resources in comparison with a sole crop. On an average, maize + soybean in 2:2 noticed 67 % higher yield advantage along with a 1.67 land equivalent ratio (LER) in comparison to the sole crop (Faruque and Singh, 2001). Panwar *et al*. (2004) concluded that maize and soybean intercropping witnessed a higher grain yield of 1.7 t/ha by the application of 120 kg N/ha and further they mentioned that higher yield parameters were recorded in sole maize and soybean as compared to an intercropped system . In Karnataka, intercropping of maize with frenchbean in the ratio of 1:2 recorded a higher maize yield of 8.07 t/ha in comparison with ricebean or soybean intercropping with maize in the same ratio (Mohan *et al*., 2005). Ibrahim *et al*. (2006) from Pakistan revealed that by sowing maize and cowpea under intercropped condition, achieved higher green fodder yield of 68.30 t/ha in a 3:1 ratio compared to rest of the treatments.

The higher green fodder yield of about 58.62 t/ha was obtained from maize and cowpea intercropping system along with the application of 150:100:100 kg of N: P_2O_5: K_2O/ha. In this maize-based intercropping system, a higher dry matter yield of 13.16 t/ha was obtained by sowing maize and sesbania in combination, along with the application of 150 kg/ha of N (Nadeem *et al*., 2009). In various ratios of maize intercropped with cowpea, maximum green fodder yield was obtained from a 1:1 ratio (65.7 t/ha) and higher grain yield of maize from 3:1 ratio system. However, higher grain yield of cowpea was observed from 1:2 ratios (Dahmardeh *et al*., 2009). Iqbal *et al*. (2012) established maize intercropped with various summer legumes and revealed that a higher green fodder yield of 13.31 t/ha was obtained by sowing maize and legumes (cowpea) in alternative rows as compared to sowing of maize and other legumes by blending or sowing in line. In Andhra Pradesh, intercropping of maize with various legumes recorded higher green fodder yield (50.10 t/ha) and dry fodder (14.2 t/ha) from maize and cowpea intercropping system in 2:1 ratio and lower green and dry fodder yield was obtained from a sole pillipesara crop (Prasanthi, 2012). In maize and sorghum based intercropping systems with legumes, higher green and dry fodder yield was obtained from sole maize or sorghum plots, which were statistically at par with sorghum or maize and cowpea sown in 2:1 ratio (Surve *et al*., 2012). From another findings of sorghum based intercropping, higher green (38 t/ha) and dry fodder yield was obtained from sorghum + cowpea sown in 2:1 ratio (Pathak *et al*., 2013). Maize grain yield was higher in sole maize, but the intercropping with legumes at 1:2 ratio yield higher maize equivalent yield under the maize and cowpea intercropping system (Choudhary *et al*., 2012).

Kheroar and Patra (2013) opined that intercropping of maize with different legumes like greengram, blackgram, soybean, and groundnut in 1:1 (additive series) and 2:1 (replacement series) observed higher grain yield. In different combinations, maize + greengram and maize + groundnut in 1:1 ratio (additive series) recorded significantly higher yield in comparison with the rest of the intercropping systems. Maximum green fodder yield (41.27 t/ha) and dry matter yield (11.15 t/ha) was obtained in the maize + cowpea intercropping system by applying 67.5 kg N/ ha and 60 kg P_2O_5/ha, which was statistically equivalent to the treatments imposing 90 kg N/ha and 30 kg P_2O_5/ha, 67.5 kg N/ha and 30 kg P_2O_5/ha, and 67.5 kg N/ha and 45 kg P_2O_5/ha. Kumar Hirpa (2014) stated that maize and haricot bean intercropping observed higher grain yield of maize under sole cropping. As the proportion of haricot increased from 1 to 3 rows between maize, there was a decrease in yield by 15.5% in maize. But, haricot bean observed a decrease in yield by 28.2%, 44.5%, and 56% in 3, 2, and 1 ratio of bean between maize. Higher grain and stover yield (18.53 and 150.37 q/ha) was obtained under sole maize crop, but the maximum maize equivalent yield was obtained by intercropping maize in 1:1 and 1:2 ratios with ricebean, cowpea, and soybean (Jha *et al*., 2015). Similar results were observed in maize and cowpea intercropping with higher green and dry fodder yield under sole maize, but when intercropped with cowpea in a 1:1 ratio, it recorded a higher green fodder yield of 48.2 t/ha, which was statistically at par to 2:1 ratio (Asangla and Gohain,

2016). In Karnal, higher productivity and profitability was obtained by sowing maize and cowpea in a ratio of 2:1 along with the application of 120 and 60 kg of N and P_2O_5/ha, respectively (Tamta *et al*., 2018). Maximum green fodder yield of 44.97 t/ha and dry matter yield of 9.49 t/ha was obtained in maize and various legume intercropping systems by sowing maize + cowpea in a 2:1 ratio, which was statistically equivalent to maize + guar with same ratio (Ginwal *et al*., 2019).

Fodder quality as influenced by intercropping

In maize and ricebean intercropping, higher crude protein (CP) and ash content and lower crude fibre (CF) content was observed by increasing the seed proportion of ricebean. In sole cropping system, higher CP and total ash with lower value of CF was observed under sole ricebean as compared to sole maize (Ayub *et al*., 2004). Similar findings have been observed by Ibrahim *et al*. (2006) in Pakistan under maize and cowpea intercropping systems. Higher CP was observed in the sole cowpea (18.10%), followed by a 25:75 ratios of maize and cowpea (15.90%) and a lower value was witnessed in the sole maize, but the maximum CF observed in the sole maize (34.51%). Iqbal *et al*. (2006) reported that a higher CP content was attained by applying 150:100:100 kg N: P_2O_5: K_2O/ ha to the maize and cowpea (12.98%) intercropping and a lower value of CP attained in the sole maize with no fertilizer (7.51%). CP and ether extract (EE) content were increased as the nitrogen dose increases, but CF shows an inverse relationship with nitrogen. Among various maize and legume combinations, maize sown with cowpea recorded higher CP content in comparison with the rest of the combinations (Nadeem *et al*., 2009). Dahmardeh *et al*. (2009) observed that in maize+cowpea intercropping higher CP and total ash content observed in sole cowpea and minimum value noticed in sole maize plot but higher value of NDF and ADF noticed in sole maize plot. Similarly, intercropping of maize with various legumes affects its quality parameters by increasing dry matter, CP and total ash content and by decreasing NDF and ADF content as compared to sole crop, which implies intercropping increases digestibility of fodder (Javanmard *et al*., 2009).

Prasanthi (2012) highlighted that intercropping of maize with various legumes in Andhra Pradesh recorded higher values of CP (7.88%), N (1.25%) and chlorophyll content (2.98 mg/g) under maize + cowpea sown in paired rows as compared to sole maize which in turn recorded higher CF content (30.74%). Ibrahim *et al*. (2012) reported that maximum values of CP and EE was observed in various maize legume intercropping systems as a proportion of legume increased with maize, but CF was greater in the sole maize. They further stated that higher CP and EE were significantly higher in all sole legumes. In the same way among various legume mixtures, maize + sesbania recorded higher CP and EE in which dry matter content, CP and digestibility of maize were superior in intercropping conditions compared to sole maize. This may be due to a decrease in NDF and ADF content in intercropped conditions (Eskandari, 2012). Sorghum and cowpea in a 2:1 ratio resulted higher CP, CF, EE and mineral matter values, but nitrogen free extract (NFE) and total digestible nutrients (TDN) were higher in sorghum + cowpea and sorghum + cluster bean sown in a 2:1 ratio (Pathak *et al*., 2013). Similarly, higher value of CP and total ash content was obtained by applying 120 kg N/ha to maize + cowpea (1:1) in comparison to sole maize with a lower N dose. Maximum values of CP and CF was obtained in the sole cowpea, but total ash was higher in 1:1 ratio combination (Asangla and Gohain, 2016). From an another experiment of cereal and legume based intercropping systems, maximum CP was observed under maize + cowpea, but a higher value of digestible dry matter content was observed under sweet sorghum + cowpea (Prajapati and Kewalanand, 2017). Tamta *et al*. (2018) at Karnal made a similar observation by sowing maize and cowpea in a 1:2 ratio with 120 kg N/ha resulted higher values of CP, EE and ash content as well as lower values of NDF, ADF, and acid detergent lignin (ADL).

Soil fertility under fodder crops as influenced by intercropping

In maize and black gram intercropping system, available P and K content in soil decreased as compared to initial values, but available N content increased due to intercropping (Sheoran *et al.,* 2010). Higher available N, P, and K content in soil was observed maize and cowpea intercropping, but maximum value observed in the sole cowpea which was statistically equivalent to 1:1 and 1:2 ratios of maize and cowpea combination and the minimum value observed in sole maize (Dahmardeh *et al*., 2010). Hirpa (2014) reported that maize intercropped with haricot bean witnessed no significant difference in organic carbon and available K, but he observed increased trend of soil pH and available N under sole bean. Further he noticed lower available P content in intercropping

condition which might be due to inter-specific competition between crops.

In Andhra Pradesh, PGPR treatment in maize based intercropping systems increased the nutrient status of soil such as available N, P and K compared to 100% recommended dose of fertilizer (RDF) with no inoculation (Damodara *et al.,* 2015). In maize and cowpea or greengram intercropping systems, there was no significant result observed with available K, but available N and P content increased significantly in soil, especially in the sole legume system with higher values. Further, maize + greengram (2:2) recorded higher values of available N, P and K and lower values under sole maize (Patel *et al*., 2017). Similar findings were reported in Karnataka in various maize and pulse-based intercropping systems with higher availability of N, P, and K, as well as soil organic carbon under sole pulse crops and maize + pulses as compared to sole maize (Girijesh *et al*., 2017).

Nutrient uptake by fodder crops as influenced by intercropping

Higher N and P uptake was observed in a pearl millet-based intercropping system by applying 100% RDF separately for pearl millet and legume. Among them, pearl millet + cluster bean showed higher N, P and K uptake than pearl millet + cowpea (Sharma and Gupta, 2002). By increasing N fertilizer dose, higher N uptake observed in maize and mungbean intercropping system. However, P uptake decreased with no change in K uptake (Chowdhury and Rosario, 2009). In corn and cowpea based intercropping system, cowpea was effective in the uptake of Ca and Mg due to higher root cation exchange capacity (CEC) and corn was effective in enhancing P and K uptake (Eskandari *et al*., 2009). According to Akhtar *et al.* (2010), wheat and cowpea intercropping system observed higher N (87.5 kg/ha) and P (12.5 kg/ha) uptake as compared to sole wheat. Similarly, among maize and various legume intercropping systems, maximum uptake of N and P was attained by maize + guar followed by maize + cowpea in 1:1 ratio (Ginwal *et al.*, 2019).

Economics of fodder crops as influenced by intercropping

Maximum net returns of 31509.45 Rs./ha along with a benefit to cost (B: C) ratio of 3.03 was obtained by intercropping ricebean with maize in 2:1 ratio compared (Zaman and Malik, 2000). In Karnataka, growing maize + frenchbean in 1:2 ratio obtained a higher economic returns of 40519 Rs./ha compared to ricebean or soybean intercropping with maize in the same ratio (Mohan *et al.,* 2005). The maize + soybean system produced highest economic returns (56043.59 Rs./ha) when compared to the sole maize plot (52643.50 Rs./ha) (Ullah *et al*., 2007). Prasanthi (2012) from Andhra Pradesh opined that under different maize legume intercropping systems, higher gross and net returns of 28,448 and 14783 Rs./ha was obtained by sowing maize and cowpea in a 2:1 ratio, respectively. But, lower economic returns were noticed in the sole pillipesara. Surve *et al*. (2012) reported similar findings in sorghum-based intercropping systems, where maximum gross and net returns (60744 and 50031 Rs./ha) with maximum B: C ratio (5.67) was obtained by sowing sorghum and cowpea in a 2:1 ratio. Similarly in Andhra Pradesh, intercropping of maize with cluster bean in skipped row recorded higher gross and net returns in comparison with the rest of the intercropping treatments. Among various fertilizer doses, 100% RDF obtained higher economic returns, which was statistically at par with 75% RDF under various intercropping systems (Naik *et al.*, 2017). In Ethiopia, higher marginal returns was obtained by growing maize + commonbean or mungbean under intercropping system along with the application of 69 kg N/ha (Takele *et al.*, 2017). Likewise, sowing maize with various legumes, particularly maize + cowpea in 2:1 ratio, produced higher net returns (38747 Rs./ha) and B: C ratio (1.78) in Karnal, Haryana as compared to other treatments (Ginwal *et al*., 2019).

CONCLUSION

The present review illustrates that cereal and legume fodder mixtures have the potential for higher fodder productivity in abandoned lands with minimum resources and are likely to play a crucial role in providing quality fodder for livestock without compromising the quantity. Cereal-legume fodder mixtures could significantly increase the dry matter and nutritive value, suggesting a better option to utilize per unit area of land for a maximum dry matter harvest without jeopardizing the quality and with the potential to minimize weed infestation. Further, fodder maize or sorghum in combination with various legumes particularly cowpea in 1:1 ratio increased the fodder yield and also enhanced the quality parameters, which eventually indicated the fulfilment of qualitative fodder production and found to be advantageous for growers along with improving the soil fertility.

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