International Journal of Bio-resource and Stress Management https://pphouse.org/ijbsm.php

Crossref

IJBSM June 2022, 13(6):654-660 Print ISSN 0976-3988 Online ISSN 0976-4038 Article AR2675

Research Article *Natural Resource Management*

DOI: HTTPS://DOI.ORG/10.23910/1.2022.2675

Influence of Integrated Nutrient and Weed Management on Growth, Yield and Quality of Soybean

M. Apon and D. Nongmaithem

Dept. of Agronomy, School of Agricultural Sciences and Rural Development, Nagaland University, Medziphema, Nagaland (797 106), India

Open Access

Corresponding meshen56@gmail.com

0000-00002-4230-4227

ABSTRACT

A study was carried out at the experimental farm of School of Agricultural Sciences and Rural Development, Nagaland University, Medziphema campus, dist. Nagaland, India during the *Kharif* season (June to October) of 2017 and 2018 to assess the influence of integrated nutrient and weed management on soybean growth, yield and quality. The split-plot design was used with three replications: three nutrient management treatments and five weed management treatments in the main-plot and sub-plot, respectively. The pooled results revealed that the application of 50% RDF+50% organic through *Rhizobium*+Phosphate Solubilising Bacteria recorded significantly lower weed density and weed dry weight. Plant height (46.12 cm), plant dry matter (10.00 g plant^{-1}), number of pods plant^{-1} (53.97), seed yield (16.28 q ha^{-1}), straw yield (22.69 q ha^{-1}), oil content (18.70%) and protein content (38.10%) were recorded highest under 75% RDF+25% organic through FYM+Phosphate Solubilising Bacteria. All of the weed treatments recorded lower weed density and dry weight over the weedy check significantly. Weed free treatment (hand weeding at 15, 30 and 45 DAS) gave highest seed yield (20.67 q ha^{-1}) and straw yield (26.28 q ha^{-1}). It was followed by propaquizafop @ 0.075 kg a.i. ha^{-1}+hand weeding at 45 DAS and pendimethalin @ 1 kg a.i. ha^{-1}+hand weeding at 30 DAS. Weed free registered highest oil content (19.38%) and protein content (38.97%) which was statistically at par with propaquizafop @ 0.075 kg a.i. ha^{-1}+hand weeding at 45 DAS and pendimethalin @ 1 kg a.i. ha^{-1}+hand weeding at 30 DAS.

KEYWORDS: Farmyard manure, pendimethalin, propaquizafop, quality, soybean, yield

Citation* (VANCOUVER)*: Apon and Nongmaithem, Influence of Integrated Nutrient and Weed Management on Growth, Yield and Quality of Soybean. *International Journal of Bio-resource and Stress Management,* 2022; 13(6), 654-660. HTTPS://DOI.ORG/10.23910/1.2022.2675.

Data Availability Statement: Legal restrictions are imposed on the public sharing of raw data. However, authors have full right to transfer or share the data in raw form upon request subject to either meeting the conditions of the original consents and the original research study. Further, access of data needs to meet whether the user complies with the ethical and legal obligations as data controllers to allow for secondary use of the data outside of the original study.

Conflict of interests: The authors have declared that no conflict of interest exists.

RECEIVED on 12th October 2021 RECEIVED in revised form on 25th May 2022 ACCEPTED in final form on 19th June 2022 PUBLISHED on 30th June 2022

1. INTRODUCTION

Soybean [*Glycine max* (L.) Merrill] is an important oilseed crop and pulse crop in the world. It is a prospective crop of the North Eastern Region of India. It plays a vital role in building soil fertility by fixing atmospheric N using root nodules as well as through the leaves incorporated on the soil at maturity. It can be grown alone or intercropped with crops such as maize and ragi on slopes and *jhum* land, terraces and plains (Konyak et al., 2016).

Both nutrient and weed management are the main prerequisites for improving soybean productivity. In Nagaland, the soybean cultivation is limited and productivity is low due to using local cultivars, lack of nutrients and inadequate fertilization (Bhattacharjee et al., 2013). However, there is good scope to increase its cultivation through integrated nutrient and weed management practices. Furthermore, integrated utilization of fertilizers, organics and biofertilizers can help achieve crop yield soil health and sustainably (Lynrah and Nongmaithem, 2017).

Chemical fertilizers meet the crop requirement for nutrients and enhance their yield; however, their continual application will cause a detrimental effect on the soil properties (Dar and Bhat, 2020; Dinesh et al., 2010). Therefore, it has become necessary to adopt integrated nutrient management comprising combined utilization of synthetic fertilizers, organic manures and biofertilizers for soil health maintenance and fertility and achieve higher productivity and monetary returns (Ellafi et al., 2011; Ram and Mir, 2006).

Organic manures are an essential source of nutrient. It is a plant nutrients storehouse supplying macronutrients and micronutrients and improving the soil properties and also enhances the efficiency of the mineral nutrient applied (Singh, 2018; Aher et al., 2015). Farmyard manure is the tool to improve the soil properties, i.e., physical, chemical and biological (Ould et al., 2010; Zhang et al., 2014). Biofertilizer is not only eco-friendly but also offers a cheaper low capital intensive. It helps in boosting farm productivity depending upon their activity of mobilizing different nutrients (Yadav and Sarkar, 2019). Phosphate solubilizing bacteria (PSB) helps solubilize soil P through the various organic acids secretion and makes it available to plants. Thereby, it reduces the excessive use of chemical fertilizers (Mahantesh et al., 2015; Abbasi et al., 2015).

One of the chief cause which limits the yield in soybean is weed infestation. Manual weeding and hoeing are generally employed to manage weeds in soybean. The most common method used for controlling weeds is hand weeding. Nevertheless, it becomes ineffective due to the non-availability of labourers, especially during crop-weed competition peak period and uneconomical due to high labour cost. Especially during the *Kharif* season, the tools and implements used for removing weeds become limited due to heavy and continual rainfall. Manual weeding and mechanical means for controlling weeds may not be effective and economical weed control as it increases the cost of cultivation and exhausts the resource base (Kumar et al., 2018; Adigun et al., 2018). So under such circumstances, various herbicides (pre-emergence and post-emergence) can be applied to effectively control annual grass and broad-leaved weeds in soybean. The use of suitable herbicides is needed to minimize weed problems. Because there is availability of a short time period for sowing soybean during *Kharif* season, farmers usually prefer post-emergence herbicides over pre-emergence herbicides for controlling weeds (Sandil et al., 2015). Hence, an integrated weed management approach is critical for maintaining the population of weeds below the economic threshold level. Therefore, considering all the given points, the present investigation was conducted to find the growth, yield, and seed quality of soybean as affected by the integrated nutrient and weed management.

2. MATERIALS AND METHODS

A field experiment was carried during the *Kharif* season (June to October), 2017 and 2018 at the experimental farm of School of Agricultural Sciences and Rural Development, Nagaland University, Medziphema campus, dist. Nagaland, India which is located at an altitude of 310 meters above sea level and located at 25°45'43'' N latitude and 95°53'04'' E longitude. The experimental farm lies in a humid subtropical region with annual rainfall ranging from 2000-2500 mm. The mean temperature ranges from 21°C-32°C during summer. Collection of soil sample was done from 0–15 cm depth with *khurpi*. The soil was sandy loam having soil pH 4.63, organic carbon (1.07%), available nitrogen (328.65 kg ha^{-1}), available phosphorus (13.44 kg ha^{-1}), and available potassium (165.87 kg ha^{-1}). The experiment field was laid out in a split-plot design with three different nutrient managements, viz., 100% RDF-N: P_2O_5: K_2O: S (20:60:40:20 kg ha^{-1}), 75% RDF+25% organic through farmyard manure (FYM)+Phosphate Solubilizing Bacteria (20 g kg^{-1} seed), and 50% RDF+50% organic through *Rhizobium* (20 g kg^{-1} seed)+Phosphate Solubilizing Bacteria (20 g kg^{-1} seed) in the main plot and five weed managements viz., weedy check, weed free (hand weeding at 15, 30 and 45 DAS), mechanical weeding at 20 and 40 DAS, pendimethalin @1 kg a.i. ha^{-1} (Pre-emergence)+hand weeding at 30 DAS and propaquizafop @ 0.075 kg a.i. ha^{-1} (Post-emergence)+hand weeding at 45 DAS in the sub-plot and replicated thrice with the plot size 4×3 m^2.

Soybean variety JS 97-52 was sown with 40×10 cm^2 spacing maintained in each plot. The seed rate was 60 kg ha^{-1}. Before planting total dose of nutrients was incorporated into the soil as basal application. The herbicides were applied with the help of a knapsack sprayer. The mechanical weeding was carried out with the help of a wheel hoe. Random selection of five healthy plants was done from each plot for recording observation on growth parameters. The observations on yield and attributing parameters were recorded at harvest. The oil content and protein content in the seed were determined by using the standard methods. Weed density and weed dry weight were recorded at 60 DAS by randomly placing a quadrate 0.5×0.5 m^2 in each plot and then converted to per square meter. The data were then subjected to square root transformation ( ) before statistical analysis. Based on the method suggested by Mani et al. (1973), weed control efficiencies were calculated.

The data of two years for different parameters observed were analyzed using standard procedures of variance analysis to statistical analysis as per Cochran and Cox, 1984 and the significant of different source of variations were tested using 'F' test at 5% level of significance.

3. RESULTS AND DISCUSSION

3.1. Weed density and weed dry weight

The major weed floras observed in the field were *Digitaria sanguinalis*, *Borreria latifolia, Cynodon dactylon, Cyperus iria, Eleusine indica*, *Cyperus kyllingia*, *Cyperus rotundus, Amaranthus viridis, Ageratum conyzoides, Cleome rutidosperma* and *Mimosa pudica*. Results in the Table 1 indicates that the weed density and weed dry weight recorded at 60 DAS under nutrient weed management showed significant differences. The lowest weed density and weed dry weight were recorded in the nutrient management treatment with 50% RDF+*Rhizobium*+Phosphate Solubilising Bacteria. And it recorded highest weed control efficiency. Application of 75% RDF+25% organic through FYM+Phosphate Solubilizing Bacteria (PSB) recorded the highest weed density and weed biomass. The application of farmyard manure to the crop might have contributed in higher weed seeds and also made soil conditions favourable for weed emergence. This is in conformity with the findings of Aggarwal and Ram (2011).

Significant variation in weed density and weed dry weight were recorded due to different weed management practices. Significantly, the highest weed density and weed dry weight were recorded in weedy check. It could be due to poor weed control favouring the grand growth of weeds. This conforms with the finding of Patel et al. (2018). Weed free (hand weeding at 15, 30 and 45 DAS) recorded the lowest weed density and weed dry weight. This was followed by propaquizafop @ 0.075 kg a.i. ha^{-1} PoE+hand weeding at 45 DAS and subsequently followed by pendimethalin @1 kg a.i. ha^{-1} PE+hand weeding at 30 DAS. This could be due to effective elimination of weeds at both pre and post-emergence stages (Kumar et al., 2018; Virk et al., 2018). Weed free also recorded highest weed control efficiency followed by propaquizafop @ 0.075 kg a.i. ha^{-1}+hand weeding at 45 DAS and pendimethalin @1 kg a.i. ha^{-1}+hand weeding at 30 DAS. Such higher weed control efficiencies were chiefly on account of effective weed control under these treatments. Sah et al. (2018) also reported similar results.

Table 1: Influence of integrated nutrient and weed management on total weed density and total weed dry weight at 60 DAS (pooled data of 2017 and 2018)

Treatment	Total weed density (no. m^{-2})	Total weed dry weight (g m^{-2})	Weed control efficiency (%)
Nutrient management			
N_1	8.37 (98.40)	7.27 (87.79)	73.39
N_2	8.73 (106.90)	7.59 (96.44)	73.36
N_3	7.96 (89.90)	6.87 (80.12)	73.67
SEm±	0.069	0.083	-
CD (p=0.05)	0.271	0.326	-
Weed management			
W_1	17.97 (323.06)	18.21 (331.77)	
W_2	1.41 (9.67)	1.87 (3.37)	99.00
W_3	10.09 (101.83)	8.64 (74.97)	77.46
W_4	3.60 (40.83)	4.88 (23.78)	92.91
W_5	1.77 (16.61)	2.61 (6.68)	98.00
SEm±	0.099	0.151	
CD (p=0.05)	0.290	0.442	

Figures within parentheses indicate the original value and the data were subjected to square root transformation (√("x+0.5")); N_1: 100% RDF-N: P_2O_5: K_2O: S (20:60:40:20 kg ha^{-1}), N_2: 75% RDF+25% organic through FYM+Phosphate Solubilizing Bacteria (PSB) @ 20 g kg^{-1} seed , N_3: 50% RDF+50% organic through Rhizobium @ 20 g kg^{-1} seed+Phosphate Solubilizing Bacteria (PSB) @ 20 g kg^{-1} seed, W_1: weedy check, W_2: Weed free (hand weeding at 15, 30 and 45 DAS), W_3: mechanical weeding at 20 and 40 DAS, W_4: Pendimethalin @ 1 kg a.i. ha^{-1} PE+hand weeding at 30 DAS, W_5: Propaquizafop @ 0.075 kg a.i. ha^{-1} PoE+hand weeding at 45 DAS

3.2. Growth parameters

The application of 75% RDF+25% organic through FYM+Phosphate Solubilizing Bacteria (PSB) resulted in highest plant height (Table 2). It was found to be at par with

Table 2: Influence of integrated nutrient and weed management on growth of soybean at 60 DAS

Treatment	Plant height	No. of primary branches	Plant dry matter accumulation (g plant^{-1})	Leaf area index (LAI)	No. of root nodules plant^{-1}	Fresh weight of nodule plant^{-1}	Dry weight of nodule plant^{-1}
Nutrient management							
N_1	37.86	3.42	7.91	1.79	27.98	0.89	0.28
N_2	46.12	4.27	10.00	2.07	31.06	0.99	0.31
N_3	41.83	3.80	9.17	2.00	36.75	1.17	0.37
SEm±	1.344	0.174	0.319	0.068	1.464	0.047	0.014
CD (p=0.05)	5.278	NS	1.251	NS	5.749	0.186	0.053
Weed management							
W_1	30.92	2.99	4.27	0.95	18.33	0.60	0.18
W_2	51.17	4.69	12.49	2.67	51.02	1.60	0.50
W_3	37.47	3.46	6.84	1.43	22.78	0.75	0.24
W_4	42.42	3.82	10.28	2.25	30.30	0.96	0.30
W_5	47.71	4.19	11.28	2.48	37.24	1.17	0.37
SEm±	0.793	0.101	0.216	0.097	1.442	0.042	0.014
CD (p=0.05)	2.313	0.294	0.630	0.284	4.208	0.123	0.041

50% RDF+50% organic through *Rhizobium*+Phosphate Solubilizing Bacteria (PSB). The influence of integrated nutrient management was evident with the development of crop growth. The availability of continuous nutrients to soybean crops due to slow nutrient release from farmyard manure throughout the crop growing period may be the reason for the superior effect on plant height (Singh et al., 2013).

The number of primary branches plant^{-1} did not vary significantly among the three nutrient management treatments. The plant dry matter accumulation plant^{-1} and Leaf area index (LAI) was recorded highest with 75% RDF+25% organic through FYM+Phosphate solubilizing bacteria (PSB). It was significantly at par with 50% RDF+50% organic through *Rhizobium*+Phosphate solubilizing bacteria (PSB). The LAI is due to the leafy growth of the plant. Better nutrition of the plants increases the leaf area index. In this case, farmyard manure application with inorganic fertilizer might have resulted in leaf size improvement leading to significant improvement in LAI. The dry matter accumulation is well reflected through the plant photosynthetic activities. The increase in dry matter production indicates superior utilization of nutrients accompanied by greater solar energy harvest. The higher dry matter production at higher fertility may lead to vigorous vegetative growth and higher LAI (Mandal and Sinha, 2004; Singh and Rai, 2004). The root nodules plant^{-1} (36.75), fresh weight nodules plant^{-1} (1.17 g) and dry weight nodules plant^{-1} (0.37 g) were found significantly highest in 50% RDF+50% organic through *Rhizobium*+Phosphate Solubilizing Bacteria (PSB) and at par with 75% RDF+5t ha^{-1} FYM+Phosphate Solubilizing Bacteria (PSB). Egamberdiyeva et al. (2004) reported that inoculated plants had a significantly higher number of root nodules than uninoculated plants.

Significantly highest plant height (51.17 cm), primary branches plant^{-1} (4.69) and plant dry matter accumulation (12.49 g plant^{-1}), number of root nodules (51.02), nodule fresh weight plant^{-1} (1.60g) and nodule dry weight plant^{-} (0.50 g) was recorded with hand weeding at 15, 30 and 45 DAS This was followed by propaquizafop @ 0.075 kg a.i. ha^{-1}+hand weeding at 45 DAS and pendimethalin @ 1 kg a.i. ha^{-1}+hand weeding at 30 DAS. This shows the distinct effect of their integrated use; as initially the herbicides limits the weed growth and later the hand weeding eliminates the fresh flush of weeds that may regenerate due to loss of persistence of the applied herbicides. It conforms with the findings of Peer et al. (2013) and Kushwah and Vyas (2004). The weedy plot recorded the minimum plant growth parameters among all the weed management treatments.

3.3. Yield and yield attributes

A significant effect on the number of pods plant^{-1} was observed due to nutrient management treatments (Table 3). The application of 75% RDF+25% organic through FYM+Phosphate Solubilizing Bacteria (PSB) recorded the highest number of pods plant^{-1} (53.97) which was at par with 50% RDF+50% organic through *Rhizobium*+Phosphate

Table 3: Influence of integrated nutrient and weed management on yield attributes, yield and quality of soybean

Treatment	Number of pods plant^{-1}	100-seed weight	Seed yield (q ha^{-1})	Straw yield (q ha^{-1})	Oil content (%)	Protein content (%)
Nutrient management						
N_1	45.13	8.89	13.87	20.18	18.50	37.15
N_2	53.97	9.42	16.28	22.69	18.70	38.10
N_3	49.55	9.26	15.08	21.71	18.61	37.86
SEm±	1.190	0.21	0.210	0.279	0.051	0.174
CD (p=0.05)	4.671	NS	0.824	1.094	NS	0.683
Weed management						
W_1	26.50	7.95	6.60	13.35	17.31	34.60
W_2	62.37	10.11	20.67	26.28	19.38	38.97
W_3	41.57	8.53	10.88	19.26	18.20	37.56
W_4	57.10	9.47	17.80	23.88	18.99	38.64
W_5	60.23	9.89	19.44	24.88	19.14	38.73
SEm±	1.184	0.189	0.274	0.357	0.132	0.292
CD (p=0.05)	3.457	0.552	0.800	1.043	0.384	0.853

solubilizing bacteria (PSB). Conversely, the treatment 100% RDF recorded the lowest number of pods plant^{-1}.

No significant variation in 100-seed weight was found due to different nutrient management treatments, which may be due to the absorption and translocation of nutrients sufficient for grain formation in all three nutrient treatments. The different nutrient management influenced the seed yield and straw yield significantly. The maximum seed yield (16.28 q ha^{-1}) was recorded with 75% RDF+25% organic through FYM+Phosphate solubilizing bacteria (PSB). It was followed by 50% RDF+50% organic through *Rhizobium*+Phosphate solubilizing bacteria (PSB) and 100% RDF. 75% RDF+25% organic through FYM+Phosphate solubilizing bacteria (PSB) recorded significantly higher straw yield (22.69 q ha^{-1}) and was at par with 50% RDF+50% organic through *Rhizobium*+Phosphate Solubilizing Bacteria (PSB). The total dry matter accumulation and other plant morphological parameters of growth, i.e., plant height and the number of branches, could be the reason for the increased seed and yield in integrated nutrient management treatment. These results congruence with the findings of Tripathi et al. (2010)

Yield and yield attributes gave significant results due to different weed management. The number of pods plant^{-1} and 100-seed weight was registered highest in weed free treatment and was at par with propaquizafop @ 0.075 kg a.i. ha^{-1}+hand weeding at 45 DAS and pendimethalin @1 kg a.i. ha^{-1}+hand weeding at 30 DAS. The highest seed yield (2.07 t ha^{-1}) and straw yield (2.63 t ha^{-1}) was recorded significantly in weed free treatment. This were followed by propaquizafop @ 0.075 kg a.i. ha^{-1}+hand weeding at 45 DAS and pendimethalin @1 kg a.i. ha^{-1}+hand weeding at 30 DAS. Vyas and Jain (2003) and Peer et al. (2013) also reported that an increase in nutrients improved the 100-seed weight, which was facilitated by reduced weed competition due to effective weed control measures. In addition, weeds removed from inter and intra row spaces provided suitable aeration owing to manipulation of soil surface and thus more availability of nutrients, light, space and water. Therefore, relatively greater values of yield and yield attributes were attained. These results also conform to Kumar et al. (2018) and Chandraker and Paikra (2015).

3.4. Quality characters

The different nutrient management did not significantly influence the oil content. Nutrient management had a significant effect on protein content in seed. 75% RDF+25% organic through FYM+Phosphate Solubilizing Bacteria (PSB) application was significantly superior to the other two nutrient treatments. Similar findings were reported by Alam et al. (2009). The application of farmyard manure enhances microbial activity of ammonifiers, nitrifiers and phosphate solubilizing bacteria. As a result, the availability of organic carbon increases, which increases root growth and nodulation, resulting in increased nitrogen and protein content. Inoculation enhances nitrogen fixation and an adequate supply of plant phosphorus, thereby enhancing the plant protein synthesis and its higher concentration in grain.

Amongst weed management, weed free registered maximum oil content (19.38) and protein content (38.97). It was significantly at par with propaquizafop @ 0.075 kg a.i.

ha^{-1}+hand weeding at 45 DAS and pendimethalin @ 1 kg a.i. ha^{-1}+hand weeding at 30 DAS. The accumulation of more nitrogen in this treatment and effective elimination of weeds may have played a vital role in improving the oil and protein content. This result corroborates with the findings of Peer et al. (2013).

4. CONCLUSION

Chemical fertilizers integrated with farmyard manure and biofertilizers obtained better growth, yield and quality of soybean. Weed free treatment (three-hand weedings) recorded higher growth, yield and quality over the rest of the weed treatments. However, concerning integrated weed management, application of propaquizafop @ 0.075 kg a.i. ha^{-1}+hand weeding at 45 DAS and pendimethalin @ 1 kg a.i. ha^{-1+}hand weeding at 30 DAS seemed to be a better option since hand weeding is comparatively costly and time-consuming.

5. REFERENCES

Abbasi, M.K., Musa, N., Manzoor, M., 2015. Phosphorus release capacity of soluble P fertilizers and insoluble rock phosphate in response to phosphate solubilizing bacteria and poultry manure and their effect on plant growth promotion and P utilization efficiency of chilli (*Capsicum annum* L). Biogeosciences Discussions 12, 1839–1873.

Adigun, J.A., Daramola, O.S., Adeyemi, O.R., Ogungbesan, A., 2018. Impact of nitrogen levels and weed control methods on growth and yield of okra (*Abelmoschus esculentus* (L.) Moench) in the Nigerian Forest-Savanna. Journal of Experimental Agriculture International 20, 1–11.

Aggarwal, N., Ram, H., 2011. Effect of nutrients and weed management on productivity of lentil (*Lens culinaris* L.) Journal of Crop and Weed 7(2), 191–194.

Aher, S.B., Lakaria, B.L., Kaleshnanda, S., Singh, A.B., Ramana, S., Ramesh, K., Thakur, J.K., 2015. Effect of organic farming practices on soil and performance of soybean (*Glycine max*) under semi-arid tropical conditions in Central India. Journal of Applied and Natural Science 7(1), 191–194.

Alam, M.A., Siddiqua, A., Chowdhury, M.A.H., Pradhan, M.Y., 2009. Nodulation, yield and quality of soybean as influenced by integrated nutrient management. Journal of Bangladesh Agricultural University 7(2), 229–234.

Bhattacharjee, S., Singh, A.K., Kumar, M., Sharma, S.K., 2013. Phosphorus, sulphur and cobalt fertilization effect on yield and quality of soybean [*Glycine max*. (L.) Merrill] in acidic soils of Northeast India. Indian Journal of Hill farming 26, 63–33.

Chandraker, A.K., Paikra, P.P., 2015. Effect of integrated weed management on weed dynamics on soybean *Glycine max* (L.) Merrill] under Chhattisgarh plain. Indian Journal of Agricultural Sciences 49, 53–58.

Cochran, W.E., Cox, G.M., 1957. Experimental Designs. Wiley, New York.

Dar, S., Bhat, R.A., 2020. Aquatic Pollution stress and role of biofilms as environment cleanup technology. In: Qadri, H., Bhat R.A., Dar, G.H., Mehmood, M.A. (Eds.), Freshwater pollution dynamics and remediation. Springer Nature, Singapore, 293–318.

Dinesh, R., Srinovasan, V., Hamza, S., Manjusha, A., 2010. Short term incorporation of organic manures and biofertilizers influences biochemical and microbial characteristics of soils under an annual crop [Turmeric (*Cucurma longa* L.)]. Bioresource Technology 101, 4697–4702.

Egamberdiyeva, D., Qarshieva, D., Davranov, K., 2004. The use of *Bradyrhizobium* to enhance growth and yield of soybean in calcareous soil in Uzbekistan. Journal of Plant Growth Regulation 23(1), 54–57.

Ellafi, A.M., Gadalla, A., Galal, Y.G.M., 2011. Biofertilizers in action: Contributions on BNF in sustainable agricultural ecosystems. E-International Science Research Journal 3, 108–116.

Konyak, M.M., Singh, A.K., Mere, V., Singh, S.K., 2016. Effect of sulphur and cobalt on yield and oil quality of soybean. Journal of the Indian Society of Soil Science 64(2), 201–204.

Kumar, S., Rana, M.C., Rana, S.S., 2018. Effect of propaquizafop alone and in mixture with other herbicides on weed dry weight and growth and yield of soybean. Journal of Crop and Weed 14(2), 149–153.

Kushwah, S.S., Vyas, M.D., 2005. Herbicides weed control in soybean (*Glycine max*.). Indian Journal of Agronomy 50(3), 225–227.

Lynrah, A., Nongmaithem, D., 2017. Effect of lime and integrated nutrient management on soybean under rainfed condition of Nagaland. International Journal of Bio-resource and Stress management 8(5), 679–683.

Mahentesh, S.P., Patil, C.S., Himanshu, V., 2015. Isolation and characterization of potent phosphate solubilizing bacteria. Journal of Microbiology, Biotechnology and Food Sciences 1, 23–28.

Mandal, K.G., Sinha, A.C., 2004. Nutrient management effect on light interception, photosynthesis, growth, dry matter production and yield of Indian mustard (*Brassica juncea*). Journal of Agronomy and Crop Science 190(2), 119–129.

Mani, V.S., Pandita, M.L., Gautam, K.C., Bhagwandas, 1973. Weed killing chemicals in potato cultivation. Indian Farming 23, 7–13.

Ould Ahmed, B.A., Inoue, M., Moritani, S., 2010. Effect of saline water irrigation and manure application on the available water content, soil salinity, and growth of wheat. Agricultural Water Management 97, 165–170.

Patel, B.D., Chaudhari, D.D., Patel, H.K., Mishra, A., Patel, V.J., Parmar, D.J., 2018. Effect of organic and weed management practices on weeds, yield and soil microbial properties in fennel. Crop Research 53(5&6), 247–251.

Peer, F.A., Hassan, B., Lone, B.A., Qayoom, S., Ahmad, L., Khanday, B.A., Singh, P., Singh, G., 2013. Effect of weed control methods on yield and yield attributes of soybean. African Journal of Agricultural Research 8(48), 6135–6141.

Ram, T., Mir, M.S., 2006. Effect of integrated nutrient management on yield and yield-attributing characters of wheat (*Triticum aestivum*). Indian Journal of Agronomy 51(3), 189–192.

Sah, D., Heisnam, P., Pandey, A.K., 2018. Weed management in okra under foot hill conditions of North Eastern Himalaya. Journal of Crop and Weed 14(1), 201–204.

Sandil, M.K., Sharma, J.K., Sanodiya, P., Pandey, A., 2015. Bio-efficacy on tank-mixed propaquizafop and imazethapyr against weeds in soybean. Indian Journal of Weed Science 47(2), 158–162.

Singh, B., 2018. Are nitrogen fertilizers deleterious to soil health? Agronomy 8(4), 48.

Singh, R., Rai, R.K., 2004. Yield attributes, yield and quality of soybean (*Glycine max*) as influenced by integrated nutrient management. Indian Journal of Agronomy 49(4), 271–274.

Singh, R., Sharma, H.B., Kumar, P., Paliwal, D.K., Kumar, P., 2013. Effect of integrated nutrient management on growth yield and nutrient uptake by soybean (*Glycine max*) cultivars. Indian Journal of Agronomy 58(3), 379–383.

Tripathi, M.K., Chaturvedi, S., Shukla, D.K., Mahapata, B.S., 2010. Yield performance and quality in Indian mustard (*Brassica juncea*) as affected by integrated nutrient management. Indian Journal of Agronomy 55(2), 138–142.

Virk, H.K., Singh, G., Sharma, P., 2018. Efficacy of post-emergence herbicides for weed control in soybean. Indian Journal of Weed Science 50(2), 182–185

Vyas, M.B., Jain, A.K., 2003. Effect of pre and post emergence herbicides on weeds control and productivity of soybean. Indian Journal of Agronomy 48(4), 309–311.

Yadav K.K., Sarkar, S., 2019. Biofertilizers, Impact on soil fertility and crop productivity under sustainable agriculture. Environment and Ecology 37(1), 89–93.

Zhang, J.B., Yang, J.S., Yao, R.J., Yu, S.P., Li, F.R., Hou, X.J., 2014. The effects of farmyard manure and mulch on soil physical properties in a reclaimed coastal tidal flat salt-affected soil. Journal of Integrative agriculture 13(8), 1782–1790.

