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Response of Fertilization of Nitrogen on Agronomical Attributes of Soybean

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Authors' contributions

This work was carried out in collaboration among all authors. Author IN carried out research work. Author NS conducted statistical analysis and completed the manuscript. Authors AP and PM assisted in drafting of manuscript. All authors read and approved the final manuscript.

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ABSTRACT

Soybean also known golden bean is a dual purpose crop grown to meet the requirement of both high protein and oil content. Fertilizers are one of the important components of farming system due to their requirement to provide essential nutrients to crop. The current research work was done to study the effect of the different rates of nitrogen fertilization on the growth and yield of soybean were studied. Field experiments were conducted at Instructional Research Farm, Krishi Nagar, Jabalpur, Madhya Pradesh, India during *kharif* season in the month of July to October in the year 2019–2020. This research has been conducted in order to examine the beneficial effects of additional application of nitrogen at grain development stage on yield attributes and yield of soybean. The experimental material was early maturing variety of soybean JS 20-34. Treatments were given in 12 combinations in the split plot design. Plant samples were collected at R1 and R3 for dry matter yield and nitrogen determination. Grain yields were determined and grain samples were collected at harvest. A positive grain yield in response to nitrogen fertilizer was observed in different treatments. These imply that additional nitrogen applications are important for

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getting higher yields. In the current research we came to the conclusion that additional nitrogen fertilizer application to soybean crop has positive impact on several agronomical attributes of the crop.

Keywords: Fertilizer; grain yield; growth; nitrogen; soybean.

1. INTRODUCTION

Soybean belonging to family leguminosae is a golden bean crop cultivated worldwide on large scale [1]. Soybean is enriched with the natural ability to biologically fix nitrogen from the atmosphere and also known for its rich source of high quality protein and essential amino-acid [2]. Additionally, it also provides good amount of dietary fibre and a very good source of oil (20%), protein (40%), carbohydrate (30%), saponins (5%), and fibre (5%) [3]. The various attractive and useful factors associated with soybean crop make it one of the most important cultivated plants globally [4]. Among all the plant based protein sources, the biological value of soybean protein is highest [5]. That is major reason behind increasing demand of this crop at global level. Various kinds of food products including soybean oil, tofu, food additives like soy lecithin and industrial products can be produced from soybean [6]. Benefits associated with this important legume makes it a multidimensional crop which can be used as oilseed, vegetarian meals and soy milk [7]. It also an eco-friendly crop playing important role in maintaining soil fertility [8]. Globally, soybean was produced 333.67 million tonnes (mt) from an area covering 120.50 million hectare (mh) in 2019-2020. In India soybean covers 11.34 mha contributing 11.22 mt of production [9]. The major soybean growing states in India are Madhya Pradesh, Maharashtra, Rajasthan, Karnataka and Telangana. However, due to onset of various abiotic and biotic factors, including imbalanced fertilization, productivity of soybean is very low in India [10]. Even-though symbiotic nitrogen (N) fixation supplies N for soybean and eliminates need for large nitrogen fertilizer application required for non-legume crops, however additional application of nitrogen in the form of fertilizer assist in increasing yield and productivity of the soybean [11]. There are several additional benefits associated with the additional application of nitrogen in the soybean including enhanced seed yield, nodules formation, improving availability of nitrogen to the crop [12]. Again, there are several constraints to biological nitrogen fixation resulting poor availability of nitrogen which ultimately will cause reduced grain formation, test weight and thus will affects crop productivity [13]. Only 25% to 60% of nitrogen in soybean dry matter comes from symbiotic nitrogen fixation, remaining requirement is fulfilled from soil nitrogen [14]. This nitrogen requirement in the crop is fulfilled by applying additional nitrogen as a basal dose [15]. Nutritional imbalance is one of the major constraints resulting lower productivity in soybean [16]. Production of crop is highly influenced with the nutrients application and availability [17]. There is interaction between amount of nutrients and crop growth stage at which it is applied [18]. Soybean crop requires fifteen essential nutrients for its growth [19]. Currently we have several research reported on effective nutrient management in soybean and how this is important to enhance yield in modern soybean varieties [20]. Legumes generally requires relatively large amount of nitrogen due to their high protein content [21].

With this background knowledge, this research was conducted to examine the affects of additional nitrogen fertilizer application on the early growth, grain yield and yield attributes of soybean cultivar JS 20-34. Monetary return was also calculated under different treatments.

2. MATERIALS AND METHODS

The Research experiment was conducted at Instructional Research Farm, Krishi Nagar, Adhartal, The Department of Agronomy, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh, India during *kharif* season in the month of July–October, 2019–2020 (Fig. 1). The topography of the experimental site was uniform with the gental slope of nearly 0.5%. Research farm was enriched with the physical facilities *viz.,* labours, agrochemicals, equipments and irrigation water etc. The analytical works were done in the laboratory of the Department of Agronomy, College of Agriculture, JNKVV, Jabalpur. Early maturing variety JS 20-34 was sown manually at the seed rate of 80 kgha^{-1} in 36 plots in split plot design. Fertilizer was applied as basal dose @ of 20:60:20 (N: P_2O_5: K_2O) Kg ha^{-1} respectively in twelve treatment combination in three replications. Additional nitrogen was applied as N_1- Top dressing of 10 kg N ha^{-1}at grain development, N_2- Foliar application of N@ 2% at grain development, N_3- Control. The selective herbicide imazethapyr @ 75 g a.i. ha^{-1} was applied at 30 days after sowing (DAS) to control weeds efficiently. Imidacloprid 17.8 SL @ 250 ml ha^{-1} was sprayed 30 days after sowing to control sucking insect pest thrips and jassids. Irrigation was applied as per treatments. Data were analyzed using ANOVA and all significant test were performed at α=0.05 level of significance.

3. RESULTS AND DISCUSSION

3.1 Growth Parameters

Nitrogen (N) is an important nutrient essential for plant growth and development. The application of nitrogen to the crop helps in enhancing above-ground vegetative growth. The growth parameters like plant height, dry matter production and crop yield are enhanced with the additional application of nitrogen in this pulse crop. In the present research work, affects of additional nitrogen application on growth and yield of soybean crop was analyzed and discussed.

The plant population of soybean under different treatments was statistically equal on account of congenial soil moisture and temperature throughout the cropping period and none of the treatments had detrimental effect on the crop. With the observation of plant height of soybean at 30 DAS, 60 DAS and harvesting stage, the maximum plant height was recorded with the foliar application of N @2% (51cm) followed by top dressing of 10 kg N ha^{-1}at grain development (48.0 cm) (Table 1). This increase in plant height could be attributed due to the increased availability of N through the leaves which might have enhanced the rate of photosynthesis and growth. These results are in agreement with findings of Sharifi et al. [22] that foliar application of 1% urea at pod filling stage of soybean resulted in higher plant height. Dass et al. [23] also reported that the treatment of 2% urea spray application caused maximum increase in growth attributes mainly plant height, which showed significant positive correlation with yield. There were no significant differences in the number of branches under different treatment of nitrogen at 30 and 60 DAS. Significant increase in the number of leaves $plant^{-1}$ was observed as a result of additional spray of N due to increased availability of nitrogen at peak period (Table 1). Application of nitrogen at grain development stage resulted increase in number of leaves$plant^{-1}$ as well as the leaf area which ultimately resulted in higher leaf area index (LAI). The higher number of leaves with RDF and foliar application @ 2% at flowering and pod filling stages due to improved growth of morphological characters was reported by Goud et al. [24]. Dry weight $plant^{-1}$was determined at 30, 60 DAS and harvesting stage. Effect of nitrogen levels on dry weight $plant^{-1}$ was found to be non-significant at 30 and 60 DAS, while the differences were significant at harvest. The maximum dry weight$plant^{-1}$ of soybean was recorded under foliar application of N @ 2% (9.0 g $plant^{-1}$) followed by top dressing of 10 kg N ha^{-1}at grain development stage (8.0g $plant^{-1}$) (Table 1). Foliar application of nitrogen @ 2% at grain development stage (9.0 g $plant^{-1}$) followed by top dressing of 10 kg Nha^{-1}at grain development stage (8.0 g $plant^{-1}$) registered significant increase indry matter production as compared to control at the time of crop harvest (Table 1). Additional application of nitrogen leads to better crop growth and photosynthetic activity which ultimately resulted in higher dry matter production $plant^{-1}$. The results are in conformity with the findings of Parasuraman et al. and Thavaprakash et al. [25,26]. Stimulated photosynthetic activity and synthesis of chloroplast and protein might have resulted in higher dry matter production of soybean [27]. Effect of nitrogen levels on leaf area was found to be non-significant at 25 and 50 DAS. Whereas there were significant differences at 75 DAS; the maximum value of (1093.7cm^2) was recorded with the foliar application of N @ 2% closely followed by top dressing of 10 kg N ha^{-1} at grain development (1051.4 cm^2), which was significantly higher than the leaf area under control (906.5 cm^2) (Table 1). The Leaf area index (LAI) was determined at 25, 50 and 75 DAS. Effect of nitrogen levels and their interaction on leaf area index was found to be non-significant at 25 and 50 DAS, but the differences were significant at 75 DAS. Foliar application of N @ 2% possessed the maximum LAI (4.2) which was at par with that under application of 10 kg Nha^{-1}(4.0).

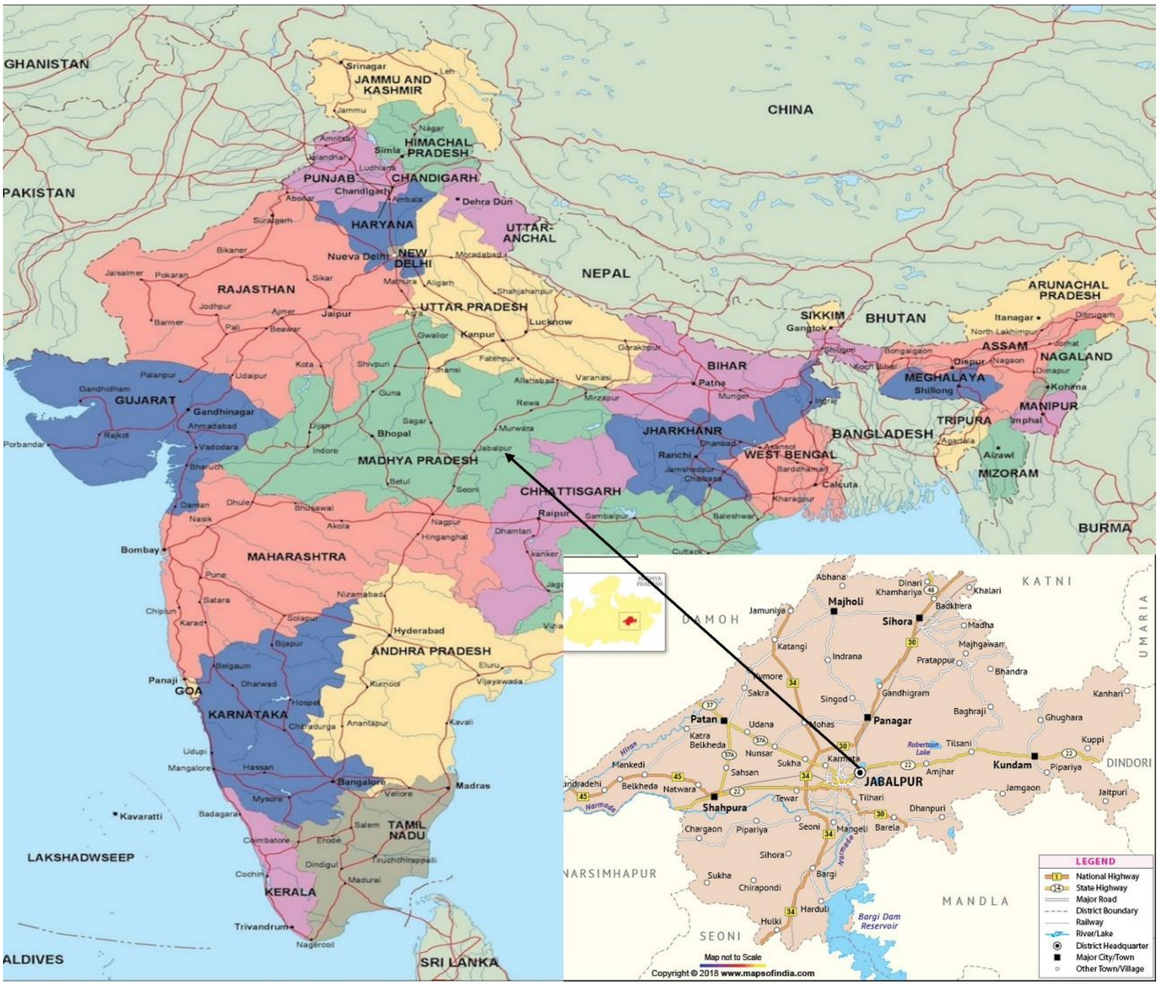

Fig. 1. Map of Jabalpur in Madhya Pradesh in India where the experiment was conducted
(Source: India Political Map. EPS Illustrator Map | Vector World Maps (Netmaps.Net)

Table 1. Effect of application of nitrogen on various growth parameters of soybean

Characters	Treatments	Effect of treatment at different days after sowing (DAS)					
		25	30	50	60	75	At harvest
Plant height (cm)	Top dressing of 10 kg Nha^{-1} at grain development (N1)	NIL	31.2	NIL	41.6	NIL	48.0
	Foliar application of N @ 2% at grain development (N2)	NIL	31.9	NIL	40.4	NIL	51.0
	Control (N_3)	NIL	31.9	NIL	39.8	NIL	44.0
Branches $plant^{-1}$	Top dressing of 10 kg Nha^{-1} at grain development (N1)	NIL	2.7	NIL	4.0	NIL	NIL

Characters	Treatments	Effect of treatment at different days after sowing (DAS)					
		25	30	50	60	75	At harvest
	Foliar application of N @ 2% at grain development (N2)	NIL	2.8	NIL	4.2	NIL	NIL
	Control (N_3)	NIL	2.6	NIL	3.9	NIL	NIL
Plant population(m^2)	Top dressing of 10 kg Nha^{-1} at grain development (N1)	35.5	NIL	NIL	NIL	NIL	35.3
	Foliar application of N @ 2% at grain development (N2)	36.4	NIL	NIL	NIL	NIL	35.3
	Control (N_3)	NIL	35.1	NIL	NIL	NIL	35.2
Leaves $plant^{-1}$	Top dressing of 10 kg Nha^{-1} at grain development (N1)	4.4	NIL	15.1	NIL	12.0	NIL
	Foliar application of N @ 2% at grain development (N2)	4.3	NIL	15.7	NIL	14.3	NIL
	Control (N_3)	4.5	NIL	14.9	NIL	10.4	NIL
LAI (Leaf Area Index)	Top dressing of 10 kg Nha^{-1} at grain development	1.7	NIL	5.3	NIL	4.0	NIL
	Foliar application of N @ 2% at grain development	1.6	NIL	5.2	NIL	4.2	NIL
	Control	1.5	NIL	5.2	NIL	3.1	NIL
Dry weight $plant^{-1}$	Top dressing of 10 kg Nha^{-1} at grain development	NIL	1.7	NIL	5.1	NIL	8.0
	Foliar application of N @ 2% at grain development	NIL	1.8	NIL	5.3	NIL	9.0
	Control	NIL	1.6	NIL	4.9	NIL	7.7

Note- Significant at Significant error of means and Critical Difference at p=0.05

3.2 Yield Attributing Characters

Data pertaining to the yield attributing characters of soybean viz., total number of pods $plant^{-1}$, filled pods $plant^{-1}$, unfilled pods $plant^{-1}$, Seed $plant^{-1}$, Seed index (g), Seed weight $plant^{-1}$(g) as influenced by the different treatments are presented in Table 2. Effect of nitrogen levels on filled pods $plant^{-1}$was found to be significant and significantly highest value (51.4) was recorded with foliar application of N @ 2% followed by top dressing of 10 kg Nha^{-1} at grain development

(47.0), which were significantly superior over control (40.0). Effect of nitrogen levels on unfilled pods plant^{-1} was found to be significant and maximum number of unfilled pod plant^{-1} of soybean was recorded in control plot (5.30). However, the number of unfilled pod plant^{-1} under foliar application of N @ 2% at grain development (3.60) was minimum. Significantly maximum number of pods plant^{-1} of soybean was recorded under foliar application of N @ 2% (55.0) closely followed by top dressing of 10 kg N ha^{-1} at grain development (52.0). The increase in number of pods due to foliar application of nitrogen could be attributed to the increase in leaf area and enhanced photosynthesis which resulted in better pod bearing and the development of pod. Similar results were observed by Aggarwal et al. [28] reported that application of 2% urea sprayed at vegetative and flower initiation stage gave highest number of pods plant^{-1} due to additive effect of macro nutrients. The results are in conformity to that reported earlier by Thakare et al., Ghosh and Joseph and Jyothi et al. [29,30,31]. The number of unfilled pod under control plot (5.30) was noted to be more than that under additional nitrogen application. This could be due to limited availability of photosynthates under control plot. Effect of nitrogen levels on number of seed pod^{-1} was found to be significant. Maximum number of seed pod^{-1} of soybean was recorded under foliar application of N @ 2% (3.10) closely followed by top dressing of 10 kg N ha^{-1}at grain development (2.81). The seedpod^{-1}of soybean varied significantly under different treatments of nitrogen. Significantly higher seed pod^{-1} was recorded (3.10) with the foliar application of nitrogen @ 2% at grain development stage, as compared with that under control (2.81). However, higher quantity of photosynthates translocating towards reproductive parts could be the reason for increase in seed pod^{-1}in case of additional nitrogen application. Effect of nitrogen levels on seed index was found to be significant. Maximum value of seed index of soybean was recorded under foliar application of N @ 2% (11.10 g) closely followed by top dressing of 10 kg N ha^{-1}at grain development (10.2 g). Effect of nitrogen levels on seed weight plant^{-1} was found to be significant. Significantly maximum seed weight plant^{-1}of soybean was recorded under foliar application of N @ 2% (8.80g) closely followed by top dressing of 10 kg Nha^{-1} at grain development (8.30 g).Which were significantly higher over control (8.00 g).This revealed that the seed weight plant^{-1}of soybean varied significantly under different treatments of nitrogen. However, increased in the number of pod plant^{-1}and seed weight has contributed to this increase in the seed weight plant^{-1}.The results are in conformity to that reported by Kaiser et al. [32]. The 100 seed weight was significantly influenced by foliar application of Nitrogen. Among all the treatments, the significantly higher 100 seed weight was recorded (11.1 g) with foliar application of N @ 2% at grain development stage closely followed by that under 10 kg N ha^{-1} (10.2 g). Enhanced photosynthetic products and amino acids due to sufficient availability of nitrogen might have improved the seed index of soybean under these treatments. Similar results have been reported by Prabhakaran and Lourduraj and Irmak et al. [33,34].

As regards the effect of nitrogen, the highest seed and straw yield of soybean were recorded under foliar application of N @ 2% (1665 and 2693 kg ha^{-1}, respectively) which showed parity to that with top dressing of 10 kg N ha^{-1}(1591 and 2552 kg ha^{-1}). However, the values under both the treatments were significantly higher over control (875 and 2029 kg ha^{-1}). The increase in the grain and straw yield with the application of additional nitrogen at grain development stage could be attributed due to the increase in photosynthetic activity and protein synthesis which improved yield attributing characteristics and ultimately seed yield of soybean. Significant increase in yield (grain and straw) with foliar application of N has also been reported by Madhavi et al., Halvankar et al., Gutiérrez-Boem et al. and Osborne and Riedell [35,36,37,38]. Morshed et al. [39] and Kang [40] also reported increase in grain yield with additional nitrogen application. Venkatesh and Basu [41] also concluded that grain yield of soybean with foliar application of 2% urea at 75 DAS were significantly increased. Effect of nitrogen levels on stover yield was found to be significant and the maximum stover yield of soybean was recorded with foliar application of N @ 2% (2692 kg ha^{-1}) closely followed by top dressing of 10 kg Nha^{-1} at grain development (2552 kg ha^{-1}) which were significantly higher over control (2029 kg ha^{-1}). Effect of nitrogen levels on biological yield was found to be significant. Maximum biological yield of soybean was recorded under foliar application of N @ 2% (4357 kg ha^{-1}) closely followed by top dressing of 10 kg Nha^{-1}at grain development (4143 kg ha^{-1}) which were significantly higher over control (2904 kg ha^{-1}). Effect of nitrogen levels on harvest index was found to be significant. The maximum harvest

Table 2. Effect of application of nitrogen on various yield attributing characters of soybean

Characters	Treatments		
	Top dressing of 10 kg Nha^{-1} at grain development (N_1)	Foliar application of N @ 2% at grain development (N_2)	Control (N_3)
Filled pod plant^{-1}	47	51.4	40
Unfilled pod plant-1	5	3.6	5.3
Number of pods plant^{-1}	52	55	45.3
Seed pod^{-1}	2.81	3.1	2.5
Seed index(g)	10.2	11.1	9.5
Seed weight plant^{-1}(g)	8.3	8.8	8
Seed yield kg ha^{-1}	1591	1665	875
Stover yield kg ha^{-1}	2552	2692	2029
Biological yield kg ha^{-1}	4143	4357	2904
Harvest index (%)	36.5	38	29.6
NUE (%)	8	9.4	0

Table 3. Economic analysis of different treatments in soybean

S. NO.	Treatments	Total cost of cultivation	GMR	NMR	B:C ratio
N_1	Top dressing of 10 kg Nha^{-1} at grain development	33628	65406	31778	1.94
N_2	Foliar application of N @ 2% at grain development	33928	68501	34573	2.01
N_3	Control	33128	37534	4406	1.04

GMR- Gross monetary returns, B:C ratio- benefit cost ratio, NMR- Net monetary return

index of soybean was recorded under foliar application of N @ 2% (38.0) followed by top dressing of 10 kg Nha-1 at grain development (36.5) which were significantly higher over control (29.6). The increased harvest index with application of RDF+foliar application of N@ 2% at grain development stage was due to increased number of podsplant-1, seed weight plant-1 and 100 seed weight. Further, sufficient availability of nutrients at flowering and grain development stage enabled plant to synthesize more photosynthates which in turn could translocate more photosynthates from source to sink effectively. The results corroborated the earlier finding of Vinothkumar et al., Kumudini et al. [42,43]. These results are in conformity with the findings of Barker and Sawyer, Lee and Yun and Kang [44,45,40].

3.3 Nitrogen Use Efficiency (NUE Percentage)

The nitrogen use efficiency (NUE) was worked out on the basis of additional nitrogen application under different treatments. Effect of nitrogen levels on NUE was found to be significant. The maximum NUE of soybean was recorded under foliar application of N @ 2% (9.4) followed by top dressing of 10 kg Nha^{-1} at grain development (8.0). The data revealed that the Nitrogen use efficiency with the additional application of N was improved significantly, being maximum under foliar application of nitrogen @ 2% at grain development stage (9.4%). The results are in conformity to the earlier findings of Ruan et al., Gaudin et al. and Li et al. [46,47,48].

3.4 Economic Outcome

The data pertaining to the cost of cultivation (ha^{-1}) and monetary returns under different treatments were estimated. The data regarding the cost of cultivation under different treatments (Table 3) showed that the cost of additional nitrogen application, foliar application of N @ 2% involved additional investment of Rs. 800ha^{-1} and the top dressing of 10 kg Nha^{-1} involved additional expenditure of Rs. 500ha^{-1} as compared to control (Rs. 33128ha^{-1}). The data regarding the gross monetary returns revealed that maximum gross income was recorded with foliar application of N @ 2% at grain development (Rs. 68501 ha^{-1}), followed by Top dressing of 10 kg Nha^{-1} at grain development (Rs. 65406 ha^{-1}), while it was lowest with control treatment (Rs. 37534 ha^{-1}). Foliar application of N @ 2% at grain development proved to be the most remunerative (Rs. 34573 ha^{-1}), followed by

Top dressing of 10 kg Nha^{-1} at grain development (Rs. 31778 ha^{-1}) where considerably higher over control (Rs. 4406).Foliar application of N @ 2% at grain development resulted maximum benefit cost ratio of 2.01, followed by Top dressing of 10 kg N ha^{-1}at grain development (1.94) which were considerably higher when compared to that under control (1.04). The cost of application of nitrogen through foliar spray was Rs. 800 only, while it gave significant increase in the seed yield and ultimately the considerable higher monetary returns was obtained. Top dressing of 10kg N ha^{-1} also gave considerably higher monetary returns when compared to the values under control (Rs. 65406, Rs. 31778 and Rs. 1.94, respectively). The results are in conformity to that reported earlier by Kuttimani and Velayutham and Zakaria et al. [49,50].

4. CONCLUSION

Supplying adequate nutrition is important for maximizing yields. Nitrogen is one of the major macronutrients required by plants for their vegetative growth. Because of high protein content legumes require more amount of nitrogen. Therefore, soybean require large amount of nitrogen which they can meet through nitrogen available in soil and from biological fixation of nitrogen through symbiotic relationships. This research work is conducted to study about effect of additional application of nitrogen on agronomical and physiological attributes of soybean crop. In addition to this we also carried out economic analysis to study about benefit cost ratio. In the current research study, we came to the conclusion that additional application of N-fertilizer in soybean is good for both growth and yield. The supplemental application of nitrogen in soybean resulted enhancement of its yield. We can a draw a conclusion that some supplementary doses of nitrogen can be applied in the soybean crop to get additional increment in the yield.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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