Plant Archives Vol. 25, Supplement 1, 2025 pp. 1222-1227 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org
DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2025.v25.supplement-1.166

EFFECT OF SPLIT APPLICATION OF NITROGEN, PHOSPHORUS AND POTASSIUM ON GROWTH AND YIELD OF SOYBEAN [*GLYCINE MAX* (L.) MERRILL]

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(Date of Receiving : 18-08-2024; Date of Acceptance : 25-10-2024)

ABSTRACT

A field experiment was conducted during *kharif*, 2023 at Experimental Farm, Department of Agronomy, College of Agriculture, Latur on clayey soil to study the effect of split application of nitrogen, phosphorus and potassium on growth and yield of soybean. The experiment was laid out in randomised block design with nine treatments and replicated thrice. The treatments were T_1 – RDF as basal, T_2 – 50% N with RDPK as basal + 50% N at 25 DAS, T_3 – 50% P with RDNK as basal + 50% P at 25 DAS, T_4 – 50% K with RDNP as basal + 50% K at 25 DAS, T_5 – 50% RDF as basal + 50% RDF at 25 DAS, T_6 – 50% NP with RDK as basal + 50% NP at 25 DAS, T_7 – 50% NK with RDP as basal + 50% NK at 25 DAS, T_8 – 50% PK with RDN as basal + 50% PK at 25 DAS and T_9 – Control. The highest values of plant height (66.32 cm), no. of branches (10.23), number of leaves (24.33), leaf area (6.31 dm^2), number of root nodules (50.67), total dry matter plant^{-1} (36.50 g), no. of pods (59.73), pod yield (32.67 g), seed yield plant^{-1} (18.57 g), seed yield (3222 kg ha^{-1}), biological yield (8746 kg ha^{-1}), GMR (161938 ha^{-1}), NMR (100487 ha^{-1}) of soybean were obtained with the application of 50% RDF as basal + 50% RDF at 25 DAS (T_5) which was at par with 50% N with RDPK as basal + 50% N at 25 DAS (T_2), 50% NP with RDK as basal + 50% NP at 25 DAS (T_6), 50% NK with RDP as basal + 50% NK at 25 DAS (T_7) and found significantly superior over rest of the treatments. Highest HI and B:C ratio were also observed with the application of 50% RDF as basal + 50% RDF at 25 DAS.

***Keywords*: Split application, gross monetary returns, net monetary returns, soybean, fertilizers

Introduction

Soybean (*Glycine max* L. Merrill) is referred to as miracle crop because it contains high protein and oil. It is an annual legume of the pea family (Fabaceae) and originated in China. It was introduced to India across the Himalayan Mountains many years ago. Soybean is becoming increasingly popular as one of the most important legumes grown in most tropical countries because of its high nutritive value and its contribution to soil fertility improvement through biological nitrogen fixation (Carsky *et al*., 2001). Soybean can be grown in varied agro climatic conditions and India is the fifth largest soybean growing country in the world after USA, Brazil, Argentina and China and is mainly cultivated in Indian states like Madhya Pradesh, Maharashtra, Uttar Pradesh and Rajasthan in India. Application of small amount of fertilizer N at sowing time as a starter dose for the crop improves the biological nitrogen fixation (BNF), whereas heavy doses of N reduce the efficacy of BNF leading to lower yield through excessive vegetative growth. Amount of nitrogen fixed by soybean varies from 70 to 120 kg ha^{-1} (Tisdale and Nelson, 1975). About half of the nitrogen in mature soybean seeds is translocated from different parts of the plant and remaining is derived from the soil. Since competition among different sinks *e.g*., for nitrogen fixation, vegetative and reproductive growth results in degeneration of nodules at the beginning of reproductive stage thereby leading to N starvation in the crop. Supplementing N at this stage may prove beneficial in raising the yield of this crop (Singh and Singh, 2013). The split application of phosphorus can help reduce phosphorus fixation to the soil. For this, the supply of a sufficient quantity of phosphorus in seeding is required to ensure an adequate initial development, especially of the root system (Soares *et al*., 2016). Potassium has long been sidelined in the crop nutrition especially in the leguminous crop where biological N-fixation is shown to be improved with potassium application (Jones *et al*., 1977). Potassium, the most abundant elements in soil is particularly important in crop physiology as it is involved in the transport of assimilates, activation of many enzymes, in the water economy of the plants and in photosynthesis. (Singh and Singh, 2013). In view of limited information available on split application of nitrogen, phosphorus and potassium in soybean, a field experiment was conducted to study the effect of split application of nitrogen, phosphorus and potassium on growth and yield of soybean.

Materials and Methods

Experimental site and treatment details

A field experiment was conducted during *kharif*, 2023 at Experimental Farm, Department of Agronomy, College of Agriculture, Latur on clayey soil to study the effect of split application of nitrogen, phosphorus and potassium on growth and yield of soybean. The experimental field was levelled and well drained. The soil of experimental plot was clayey in texture, low in available nitrogen (229.6 kg ha^{-1}), medium available phosphorus (17.6 kg ha^{-1}) and high in available potassium (447.28 kg ha^{-1}). The soil was moderately alkaline in reaction having pH 7.8. The experiment was conducted in randomized block design with nine treatments replicated thrice. The treatments were T_1 – RDF as basal, T_2 – 50% N with RDPK as basal + 50% N at 25 DAS, T_3 – 50% P with RDNK as basal + 50% P at 25 DAS, T_4 – 50% K with RDNP as basal + 50% K at 25 DAS, T_5 – 50% RDF as basal + 50% RDF at 25 DAS, T_6 – 50% NP with RDK as basal + 50% NP at 25 DAS, T_7 – 50% NK with RDP as basal + 50% NK at 25 DAS, T_8 – 50% PK with RDN as basal + 50% PK at 25 DAS and T_9 – Control. The gross plot size of each experimental unit was 5.4 m x 4.5 m and net plot size was 4.5 m x 3.9 m respectively. Sowing was done by dibbling at the spacing 45 cm x 5 cm with seed rate of 65 kg ha^{-1}. The soybean variety MAUS-158 was used for this experiment. The recommended cultural practices and plant protection measure were undertaken. The recommended dose of fertilizer of 30:60:30 NPK kg ha^{-1} was applied. The nitrogen, phosphorus and potassium were applied in split as per treatments through urea, SSP and MOP respectively. Data on various variables were statistically analysed by analysis of variance (Panse and Sukhatme, 1967).

Methodology

Plant height (cm)

The plant height was measured in cm from ground level to the base of top most fully opened leaf at various observation dates starting from 30 DAS of five randomly selected plants and the mean plant height was worked out.

Number of branches $plant^{-1}$

The number of branches emerging directly from main stem was counted. The number of branches $plant^{-1}$ from the five observational plants were counted at 15 days interval from 30 DAS till harvest. The average of five plants was expressed as number of primary branches per plant.

Number of functional leaves $plant^{-1}$

Total number of trifoliate functional leaves born on each randomly selected plants were counted and recorded at different observation dates during growth stages of crop up to harvesting. All the fully opened leaves from each plant were recorded as functional leaves. The leaves which are dried more than half of its area were excluded while counting the functional leaves.

Leaf area $plant^{-1}$ (dm^2)

Leaf area was calculated with randomly selected five plant samples. The leaves of samples were grouped as small, medium and large. The leaf area $plant^{-1}$ (dm^2) was measured by taking length and breadth of each leaf and multiply it with the leaf factor and number of leaves. Then averaging and converted on plant basis.

$$\text{Leaf area (LA)} = L \times B \times N \times K$$

Where,

LA = Leaf area (dm^2)

L = Maximum length of leaf (cm)

B = Maximum breadth of leaf (cm)

N = Number of leaves under particular group

K = Leaf area constant (0.786, Shinde, L. R. 2023)

Number of root nodules $plant^{-1}$

Randomly selected one plant from each plot of the experimental field was uprooted and cleaned. Number of nodules arises on uprooted plant roots were counted.

Total dry matter accumulation plant^{-1}

The weight of dry matter is an index of productive capacity of the plants. Hence, one representative plant from each net plot was randomly uprooted at each observation. The roots of the plant uprooted for dry matter study from each net plot were removed. After removal of roots, plant parts were sun dried in the first instance and oven dried at 65 ± 2º C temperature for 48 hours. The constant weight was recorded as total dry matter weight (g) plant^{-1} for each treatment.

Number of pods plant^{-1}

Total number of pods plant^{-1} were counted from randomly selected five plants of each net plot at the time of harvest.

Pod yield plant^{-1}

Matured pods were collected from the five randomly selected plants and weighed it. Pod yield plant^{-1} was recorded in grams (g).

Seed yield plant^{-1}(g)

Weight of seed plant^{-1} was recorded after harvest. The samples constituted of five randomly tagged plants from each net plot were cleaned and dried. Weight was recorded in grams

Seed yield (kg ha^{-1})

After harvesting, the plants from each net plot were threshed and seeds were cleaned by winnowing. The cleaned seeds obtained from each net plot were weighed in kg which was then converted into seed yield (kg ha^{-1}) by multiplying with hectare factor.

Biological yield (kg ha^{-1})

The biological yield was recorded by the following formula,

Biological yield = Seed yield + Straw yield

Harvest index (%)

Harvest index indicates the efficiency of plant material to convert the photosynthates into the economic yield and it is worked out as

$$HI = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

Where, Biological yield = Seed yield + Straw yield

Gross monetary returns (ha^{-1})

The gross monetary returns (ha^{-1}) occurred due to different treatments in the present study were worked out by considering market prices of economic product, by product and crop residues during the experimental year.

Net monetary returns (ha^{-1})

The net monetary returns (ha^{-1}) of each treatment were worked out by deducting the cost of cultivation (ha^{-1}) of each treatment from the gross monetary returns (ha^{-1}) gained from the respective treatments.

Benefit: Cost ratio (B:C)

The benefit: cost ratio of each treatment was calculated by dividing the gross monetary returns with the mean cost of cultivation.

Statistical analysis and interpretation of data

Data obtained on various variables was analysed by "Analysis of Variance Method" (Panse and Sukhatme, 1967). The total variance (S^2) and degree of freedom (n-1) were partitioned into different possible sources. The variance due to replication effects and treatment effects of fertilizer were calculated and compared with error variance for finding out 'F' value and ultimately for testing of significance at P = 0.05 wherever the results were found significant. Critical differences were also calculated for comparison of treatment mean at 5% level of significance (CD at P = 0.05) whenever the results were found to be significant.

Results and Discussion

Growth attributes

The data presented in Table 1 showed that among various treatments, significantly higher plant height plant^{-1} (66.32 cm), number of branches plant^{-1} (10.23), number of functional leaves plant^{-1} (24.33), leaf area plant^{-1} (6.31 dm^2), number of root nodules plant^{-1} (50.67), number of pods plant^{-1} (59.73), dry matter plant^{-1} (36.50 g) of soybean were recorded with the application of 50% RDF as basal + 50% RDF at 25 DAS (T_5) which was at par with the application of 50% N with RDPK as basal + 50% N at 25 DAS (T_2), 50% NP with RDK as basal + 50% NP at 25 DAS (T_6), and 50% NK with RDP + 50% NK at 25 DAS (T_7) and found significantly superior over rest of the treatments. The split application of major nutrients, which increased the nutrient availability during grand growth period of the crop resulting increased the growth attributes of soybean. The results are in close agreement with the findings of Orellana *et al.* (1990), Yinbo *et al.* (2002), Singh and Singh (2013).

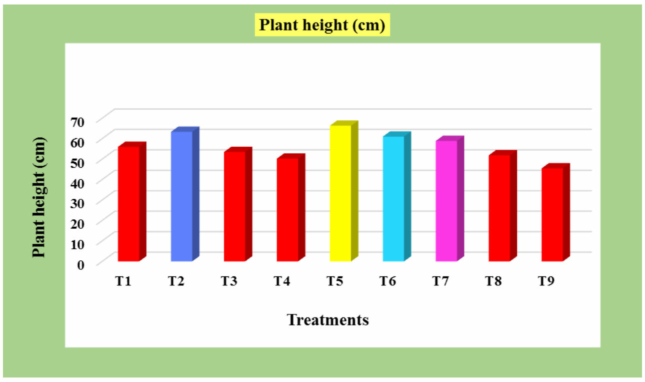

Fig. 1: Mean plant height (cm) as influenced by different treatments at harvest

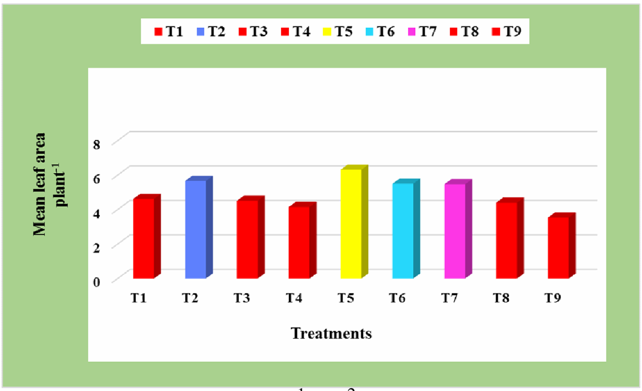

Fig. 2: Mean leaf area plant^{-1}(dm^2) as influenced by different treatments at various growth stages of crop

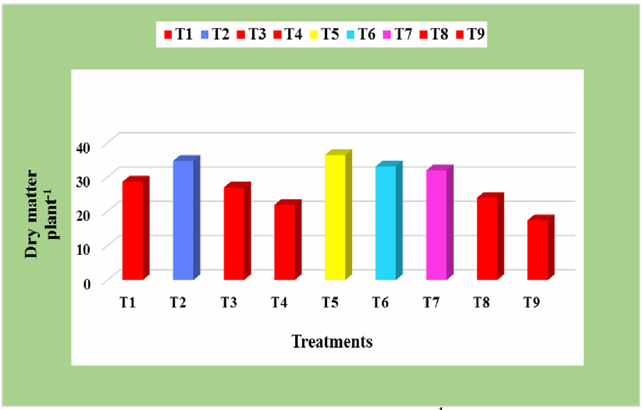

Fig. 3: Mean weight of dry matter plant^{-1} as influenced by different treatments at harvest

Yield attributes:

Application of 50% RDF as basal + 50% RDF at 25 DAS (T_5) recorded significantly higher values of no. of pods (59.73), pod yield (32.67 g) and seed yield plant^{-1} (18.57 g) of soybean (Table 2), which was at par with the application of 50% N with RDPK as basal + 50% N at 25 DAS (T_2), 50% NP with RDK as basal + 50% NP at 25 DAS (T_6) and 50% NK with RDP + 50% NK at 25 DAS (T_7) and found significantly superior over rest of the treatments. This might be due to split application of major nutrients which helped in regaining photosynthetic efficiency of crop and thereby increasing the crop yield. Similar findings are confirmed with the report of Gan *et al.* (2003) Yadav and Chandel (2010), Niranjan *et al.* (2015) Billore and Ramesh (2016) and Patil *et al.* (2019).

Yield and economics:

Data presented in Table 2 reveals that seed yield (3222 kg ha^{-1}), biological yield (8746 kg ha^{-1}), GMR (161938 ha^{-1}) and NMR (100487 ha^{-1}) of soybean were obtained with the application of 50% RDF as basal + 50% RDF at 25 DAS (T_5) which was at par with 50% N with RDPK as basal + 50% N at 25 DAS (T_2), 50% NP with RDK as basal + 50% NP at 25 DAS (T_6), 50% NK with RDP as basal + 50% NK at 25 DAS (T_7) and found significantly superior over rest of the treatments. Highest HI and B:C ratio were also observed with the application of 50% RDF as basal + 50% RDF at 25 DAS. It might be due to adequate supply of nutrients as per crop need through split application of major nutrients which enhanced growth and yield attributes of the soybean crop resulting in higher yield and thereby GMR and NMR. Results are in conformity with the findings of Krishnamohan and Rao (1998) and Khalili *et al.* (2020).

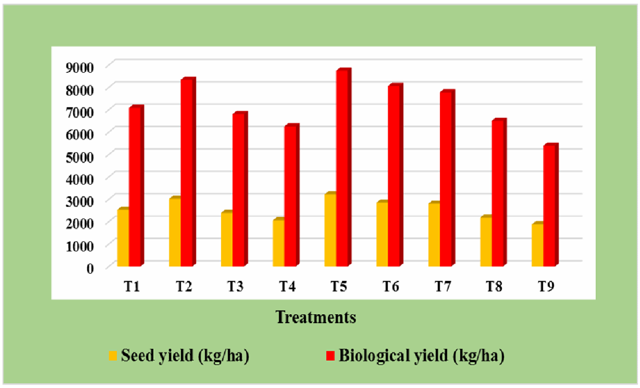

Fig. 4: Seed yield, biological yield as influenced by different treatments at harvest

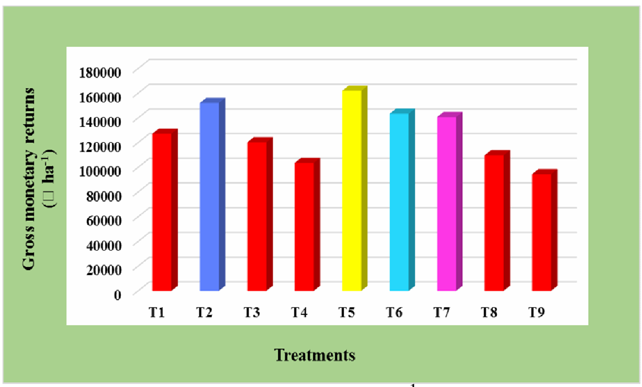

Fig. 5: Gross monetary return (ha^{-1}) as influenced by various treatments

Conclusion

It can be concluded that the split application of 50% RDF as basal + 50% RDF at 25 DAS was proved most efficient and recorded higher values of all growth attributes, yield attributes, GMR and NMR closely followed by the application of 50% N with RDPK as basal + 50% N at 25 DAS (T_2), 50% NP with RDK as basal + 50% NP at 25 DAS (T_6) and 50% NK with RDP as basal + 50% NK at 25 DAS (T_7).

Table 1: Plant height, number of branches plant^{-1}, number of leaves plant^{-1}, leaf area plant^{-1}, number of root nodules plant^{-1} and total dry matter plant^{-1} as influenced by different treatments

Treatment	Plant height (cm)	No. of branches plant^{-1}	No. of leaves plant^{-1}	Leaf area plant^{-1} (dm^2)	Number of root nodules plant^{-1}	Total dry matter plant^{-1} (g)
T_1- RDF as basal	55.99	8.50	19.27	4.62	42.00	28.68
T_2- 50% N with RDPK as basal + 50% N at 25 DAS	63.33	9.50	23.13	5.66	47.67	34.77
T_3- 50% P with RDNK as basal + 50% P at 25 DAS	53.45	8.33	17.93	4.51	41.67	27.01
T_4- 50% K with RDNP as basal + 50% K at 25 DAS	50.25	7.77	16.60	4.15	34.33	21.95
T_5- 50% RDF as basal + 50% RDF at 25 DAS	66.32	10.23	24.33	6.31	50.67	36.50
T_6- 50% NP with RDK as basal + 50% NP at 25 DAS	61.00	9.20	22.40	5.50	46.33	33.15
T_7- 50% NK with RDP as basal + 50% NK at 25 DAS	58.89	8.93	21.53	5.47	45.00	31.99
T_8- 50% PK with RDN as basal + 50% PK at 25 DAS	51.85	8.10	17.27	4.40	36.33	23.98
T_9- Control	45.50	6.30	14.67	3.54	20.67	17.45
SE (m) ±	2.73	0.45	1.04	0.28	1.93	1.60
CD at 5%	8.19	1.35	3.12	0.85	5.79	4.79

Table 2: No. of pods plant^{-1}, pod yield plant^{-1}, seed yield plant^{-1}, seed yield, biological yield, harvest index, GMR, NMR and B:C ratio as influenced by different treatments.

Treatment	No. of pods plant^{-1}	Pod yield plant^{-1} (g)	Seed yield plant^{-1} (g)	Seed yield (kg ha^{-1})	Biological yield (kg ha^{-1})	HI (%)	GMR (ha^{-1})	NMR (ha^{-1})	B:C
T_1- RDF as basal	50.67	20.71	14.25	2532	7085	35.73	127258	68857	2.17
T_2- 50% N with RDPK as basal + 50% N at 25 DAS	57.43	31.23	18.14	3025	8339	36.38	152037	91286	**2.50**
T_3- 50% P with RDNK as basal + 50% P at 25 DAS	48.87	18.53	12.91	2392	6805	35.15	120222	61571	2.05
T_4- 50% K with RDNP as basal + 50% K at 25 DAS	45.20	16.47	11.48	2062	6257	33.54	103636	46035	1.80
T_5- 50% RDF as basal + 50% RDF at 25 DAS	59.73	32.67	18.57	3222	8746	37.55	161938	100487	**2.64**
T_6- 50% NP with RDK as basal + 50% NP at 25 DAS	54.60	29.53	16.61	2853	8064	35.45	143392	82991	**2.37**
T_7- 50% NK with RDP as basal + 50% NK at 25 DAS	53.67	28.83	16.47	2800	7778	35.34	140728	80677	**2.34**
T_8- 50% PK with RDN as basal + 50% PK at 25 DAS	47.33	17.87	12.60	2183	6504	33.73	109718	51767	1.89
T_9- Control	43.03	14.62	11.05	1880	5395	35.39	94489	44238	1.88
SE (m) ±	2.63	1.30	0.71	142	368	-	7090	7090	-
CD at 5%	7.88	3.90	2.14	427	1102	-	21254	21254	-

References

Billore, S.D. & Ramesh, A. (2016). Nitrogen use efficiency in soybean. *Soybean Research*, **14**(2): 32-38.

Carsky, R.J., Sanginga, N., Okogun, J.A., Vanlauwe, B., Diels, J. & Dashiell, K. (2001). Nitrogen contribution of promiscuous soybeans in maize based cropping systems. *Sustaining soil fertility in West Africa*, **58**: 157-177.

Gan, Y.B., Tu, X.W. & Tian, R.J. (2003). Study on optimum timing of nitrogen application to soybean. *Soybean Science*. **17**(5), 287-91.

Jones, G.D., Lutz, J.A. & Smith, T.J. (1977). Effects of phosphorus and potassium on soybean nodules and seed yield. *Agronomy Journal*, **69**(6): 1003-1006.

Khalili, A., Dhar, S., Mohammadi, M. & Rasooli, M. (2021). Effect of nitrogen on yield and yield attributes of soybean in Kunar, Afghanistan. *e-planet.* **19**(1), 46-49.

Krishnamohan, K. & Rao, L.M. (1998). Effect of *Bradyrhizobium japonicum* strains and N on growth, N2 and yield of soybean genotypes during monsoon seasons. *J Res ANGARU*, **26**(3): 28-32.

Niranjan, P., Vyas, M.D. & Maravi, P.S. (2015). Effect of methods of nitrogen application on growth and productivity of soybean (*Glycine max* L. Merrill). *Soybean Research.* **13**(2), 91-99.

Orellana, M., Barber, R.G. & Diaz, O. (1990). Effect of deep tillage and fertilization on the population, growth and yield of soybean during an exceptionally wet season on a compacted sandy-loam. *Soil and Tillage Research*. **17**(2), 47-61.

Panse, V.G. & Sukhatme, P.V. (1967). *Statistical methods for Agricultural Workers.* (1st Edn.), ICAR New Delhi.

Patil, V.S., Rathod, B.G., Andhle, R.P., Patil, S.R., Jamdade, P.G. & Tambe, A.D. (2019). Role of potassium balanced and split of fertilizers for enhancing production and quality of soybean on Inceptisol. *Journal of Agriculture Research and Technology*, **44**(1): 23.

Shinde, L.R., Suryavanshi, V.P., Shaikh, H.M., Bhosale, N.U. & Choudhari, B.K. (2023). Effect of different spacing and nutrient management on growth and yield of soybean (*Glycine max* L. Merr.). *The Pharma Innovation Journal*, **12**(11): 2261-2264.

Singh, H. & Singh, G. (2013). Effect of potassium and split application of nitrogen on yield attributes and yield of soybean [*Glycine max* (L.) Merrill]. *Agricultural Science Digest-A Research Journal*, **33**(4): 264-268.

Soares, M.M., Sediyama, T., Neves, J.C.L., Santos, H.C.D. & Silva, L.J.D. (2016). Nodulation, growth and soybean yield in response to seed coating and split application of phosphorus. *Journal of Seed Science*, **38**(01): 30-40.

Tisdale, S.L. & Nelson, W.L. (1975). Soil fertility and fertilizers. *Soil Science*, **101**(4): 346.

Yadav, R. & Chandel, A.S. (2010). Effect of nitrogen and phosphorus nutrition at different physiological stages of soybean on yield and grain quality in Uttarakhand hills. *Progressive Agriculture*. **10**(2), 256–9.

Yinbo, G., Stulen, I., Posthumus, F., Keulen, H., Van & Kuiper P.J.C. (2002). Effect of nitrogen application at different growth stages of soybean. *Nutrient Cycling in Agro Ecosystems*. **62**(2), 163-74.