Fertilizer strategies to boost Mungbean **(Vigna radiata L.) yield: A plan to combat food security challenge**

Arshad Hussain[1*], Zoma Saleem[2], Saeeda Khanum[2], Ali Afzal[3], Mahwish Safdar[4], Nadia Manzoor[5], Waseem Hassan[6], Zeenat Javeed[6], Muhammad Ali[7], Muhammad Ameen[8], Salman Ahmad[9], Ilyas Ahmad[10]

[1]Agronomic Research Station Bahawalpur- 63100, Punjab, Pakistan

[2]Barani Agriculture Research Institute Chakwal-48800, Punjab, Pakistan.

[3]Institute of Soil Chemistry and Environmental Sciences, Kala Shah Kaku, Sheikhpura-811105, Punjab. Pakistan

[4]Department of Silviculture, School of Forestry, Beijing Forestry University, Beijing- 100083, China

[5]Regional Agricultural Research Institute, Bahawalpur, 63100, Punjab, Pakistan

[6]Soil and Water Testing Laboratory for Research, Bahawalpur, 63100, Punjab, Pakistan

[7]Institute of Agro-Industry and Environment, Islamia University Bahawalpur-63100, Punjab, Pakistan

[8]Department of Soil Science, Faculty of Agriculture and Environment, Islamia University Bahawalpur-63100, Punjab, Pakistan

[9]Department of Agronomy, Faculty of Agriculture and Environment, Islamia University Bahawalpur-63100, Punjab, Pakistan

[10]Pesticide Quality Control Laboratory Multan-59300, Punjab, Pakistan

*e-mail: ranaarshadb@gmail.com

Abstract

Mungbean (Vigna radiata L.) is an important pulse crop having high nutritive value. It not only plays an important role in human diet but also in improving the soil fertility by fixing the atmospheric nitrogen. Balanced nutrient application enhances mungbean growth and yield. Different soils require various doses of fertilizers for improve the better yielding under different ecological zones. Nevertheless, it has been reported that recommended application of nutrients can increase the yield and agronomic parameters. Therefore, a field experiment was conducted at the research area of Regional Agricultural Research Institute, Bahawalpur under the prevailing conditions of Bahawalpur to evaluate the response of mungbean under different doses of fertilizer application. The experiment was laid out in Randomized Complete Block Design (RCBD) having three replications. The experiment was comprised of ten treatments along with control;

only P and K application @ 34 and 25 kg ha^{-1} ; N, P and K application @ 12, 34 and 25 kg ha^{-1}; N, P and K application @ 23, 34 and 25 kg ha^{-1} ; N, P and K application @36, 34 and 25 kg ha^{-1} ;only N and K application @ 23 and 25 kg ha^{-1} ; N, P and K application @ 23, 23 and 25 kg ha^{-1} ; N, P and K application @ 23, 46 and 25 kg ha^{-1} ; only N and P application @ 23 and 34 kg ha^{-1} ; N, P and K application @ 23, 34 and 12 kg ha^{-1}; N, P and K application @ 23, 34 and 36 kg ha^{-1} respectively. The crop was harvested at maturity after 65days of sowing. The maximum plant height, fresh and dry weight of shoots and roots were observed in the treatment where N, P and K was applied @ 23, 46 and 25 kg ha^{-1}. Whereas, minimum plant height, fresh and dry weight of shoots and roots was recorded in the plot where no fertilizer was applied (control). The former dose of fertilizer (23:46:25 NPK kg ha^{-1}) significantly improved 30.44 % yield as compared to control and performed better with respect to other treatments. It has been concluded that proper dose of fertilizer improved the yield of mungbean under climatic conditions of Bahawalpur; however different soil require diverse application of fertilizers.

Keywords: Munbean, N, P, K fertilizers, mungbean yield

Tob Regul Sci. ™ 2022;8(1): 4149-4157
DOI: doi.org/10.18001/TRS.8.1.311

Introduction

Mungbean (Vigna radiata L.) is one of the humanity's oldest food crops, originated in the fertile crescent of the near east (Smýkal et al. 2015; Fuller 2011). It is an annual, herbaceous, self-pollinating plant that is raised as a vegetable, grain, foodstuff, green manure and livestock feed in Pakistan especially in South Asia where they are a major source of vegetable proteins and micronutrients including iron for poorer sections of the population(Golkar and Karimi 2019). In South Asia (Bangladesh, India and Pakistan), the demand for pulses is increasing, but since the early 1960s crop area and production have not increased. China's total mungbean output and export ranks first in the world, but there is no contribution of Pakistan in export market (Li et al. 2017). In Pakistan, mungbean is grown on an estimated 127,500 ha. Its Production is concentrated in Southern Punjab, and also grown in major growing areas of Balochistan, Khyber Pakhtunkhwa and Sindh (Rani et al. 2018). The total annual harvest is ~1 million tons. The export volume is ~150,000–250,000 tons. Baicheng is the main mungbean producing area in China. Its total annual output is ~100,000 tons, and its export volume is ~45% of the national total. Therefore, high mung yield and quality are of great importance to China, and those countries that import it, because of the high demand of mungbean in various use.

Mungbean (Vigna radiata L.) is a sub-tropical, short duration and drought resistant cultivated legume ofthe family Phaseoleae (Chowdhury and Hassan 2013).It also refurbishes the fertility of soil by fixing atmospheric nitrogen through root nodules. The farmers have been taking low yield due to many constrains. Among those the fertilizer requirements mostly phosphorus and potassium have vital importance which are not properly supplied to the crop(Itelima et al. 2018). (Marmot et al. 1991) reported that grain yield was increased with increasing phosphorus rates from 0- 50 kg ha^{-1}. Mungbean crops typically require a lot of nitrogen to achieve high yields. Although they are inoculated to fix nitrogen, this nitrogen may not be enough to supply the crop's needs.Nitrogen(N), phosphorus (P), and potassium (K) are essential and present in high levels in mungbean, and play important roles in its growth, development, high yield and significantly affect many mungbean traits(Liang et al. 2020). When soil N levels are low (total N content <0.05%), the application of a small amount of N fertilizer induces rhizobia formation and promotes the growth of strong mungbean seedlings(Yin et al. 2018). During the early growth stages before the branches develop, mungbean cannot efficiently fix atmospheric N because it has a few or no rhizobia. Increasing the application of N fertilizer during the early growth period promotes vegetative growth and creates conditions favoring high yield (Paler and Alcantara 2021). As the plant grows, the rhizobia increase and its ability to fix atmospheric N improves; however, during the late growth period, rhizobia activity is inhibited if excess N fertilizer is applied(Mia and Shamsuddin 2010). In this situation, flower bud differentiation and yield formation are impedes. P fertilizer promotes root growth, disease resistance, drought tolerance, and enhances nutrient and water absorption in the seedlings after they have depleted their endosperm reserves. K fertilizer improves sugar metabolism, enhances osmotic cell concentration, maintains stomatal guard cell turgor, helps regulate stomatal opening, participates in photosynthesis, enhances drought resistance, and increases yield(Yin et al. 2018).

Appropriate use of fertilizers is of great importance to crop growth and productivity; however, mungbean growth and development have been seriously affected, and its yield and quality have declined, as a consequence of low fertilization levels and imbalanced N, P, and K fertilization (Keatinge et al. 2011). Moreover, excessive fertilizer application has affected agricultural product quality, altered soil microecology, and enhanced soil-borne diseases(Shen et al. 2018). Mungbean yield and quality, therefore, can also be improved by the balanced use of fertilizers and by properly managing manure use (Naeem et al. 2006).

This study was conducted to determine the effects of N, P, and K fertilizers and their interactive effect on yield and yield components. To predict the changing trend and the maximum values of yield and its components with different N, P, and K levels. To generate the high yield and to improve yield components via effective and balanced fertilization. This study provides support for efficient cultivation of mungbean for high production under climatic conditions of Bahawalpur.

Materials and methods

Experimental site

Field trials were operatedduring 2019–2021 at the research area of Regional Agricultural Research Institute (RARI), Bahawalpur (27.2046°N; 77.4977°E), and Punjab Province, Pakistan. This region has the climate characteristics of desert. During the year, there is virtually no rainfall in Bahawalpur. According to Köppen and Geiger, this climate is classified as BWh. The average annual temperature is 26.1 °C (79.0 °F) in Bahawalpur. The rainfall here is around 223 mm (8.8 inch) per year. .Around 3852.73 hours of sunshine is counted in Bahawalpur throughout the year.

Experimental and planting materials and design

The Bahawalpur Mung-17 variety was used as a planting material having high yield, good quality and drought tolerant. It is widely planted locally and was bred by the Regional Agricultural Research Institute, Bahawalpur. The fertilizer sources used for N fertilizer (urea containing 46% N), P fertilizer (Di Ammonium Phosphate containing 46%P_2O_5), and K fertilizer (potassium sulfate containing 50% K_2O) were applied according to treatment's plan.

The experiment was comprised of ten treatments along with control; only P and K application @ 34 and 25 kg ha^{-1} ; N, P and K application @ 12, 34 and 25 kg ha^{-1}; N, P and K application @ 23, 34 and 25 kg ha^{-1} ; N, P and K application @36, 34 and 25 kg ha^{-1} ;only N and K application @ 23 and 25 kg ha^{-1} ; N, P and K application @ 23, 23 and 25 kg ha^{-1} ; N, P and K application @ 23, 46 and 25 kg ha^{-1} ; only N and P application @ 23 and 34 kg ha^{-1} ; N, P and K application @ 23, 34 and 12 kg ha^{-1} ; N, P and K application @ 23, 34 and 36 kg ha^{-1}, respectively. All treatments were arranged in a randomized complete block with three replications for a total of 69 trial plots. Before sowing, soil samples (pre-sowing) from experimental area were collected, processed and analyzed. The methods used for soil analysis have been described by (WIswAR et al. 1995). Physical and chemical soil analysis showed the soil is loamy and aerated having pH 8.3. The top soil (0-15-cm) layer contains 0.49% organic matter, 4.6 ppm available P, and 123 ppm available K. After soil analysis, prepared the land with recommended methods. The seeds were soiled with hand drill at a seed rate of 23 kg ha^{-1}.

Each plot had an area of 22.5 m^2 (9 m long, 2.4 m wide), rows spacing ~60 cm apart. The plants were thinned at the two-leaf stage to a uniform density of 150,000 plants ha^{-1}. The fertilizers were applied to soil as a basal fertilizer to a depth of 15 cm when the seeds were sown. All P, K and ½ N were applied at sowing and remaining ½ N will be applied at first irrigation to avoid Nitrogen losses. (Table 2). Intercultural operations such as thinning, weeding, re-sowing, drainage, irrigation and plant protection measures were taken as and when necessary and kept usual and uniform for all the experimental plots.

Measurement of mungbean yield and yield components

Pod Maturity in mungbean is not uniform because the plants flower over extended time. This makes difficult to decide when to harvest. However,in this experiment, after 65 days all plants were hand-harvested when one half to two third of the pods were mature within a 10.8m^2 area (two 9m long rows) of each plot. A 10.8m^2 sample area was used to measure the yield per hectare. The seeds were first dried to 13% -15 %moisture before yield determination. The harvested plants were swathed to allow further maturity of the pods and further threshing.

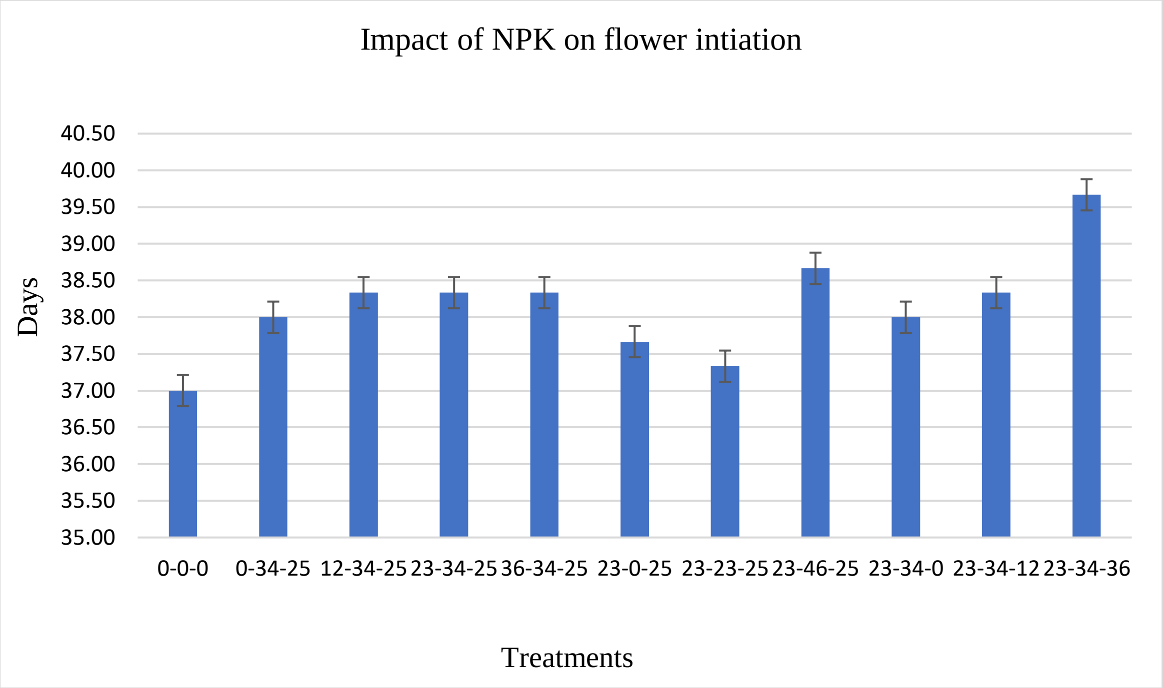
Selected three locations of 1m^2 in each plot randomly at the stage of physiological maturity, counted the pods per plant, and the 1000-grain weight was measured for five plants per plot and then average was calculated. The pods per plant were calculated from the average pods of five samples. For 1000-seed weight, 1000 seeds were weighed three times and the average weight was calculated. Grain yield was recorded by harvesting 1m^{2}per plot. Grains were threshed and weighed manually. Grain yield was then converted to get the final grain yield in kgha^{-1}. Calculated Grain yield data regarding square meter was then converted into the final grain yield in kgha^{-1}. Collected data were analyzed following the analysis of variance using statistically by using computer application / software Statistics 8.1 and treatment means were compared by using least significant difference (LSD) test at 5% probability level (Kibite and Evans 1984).

Results

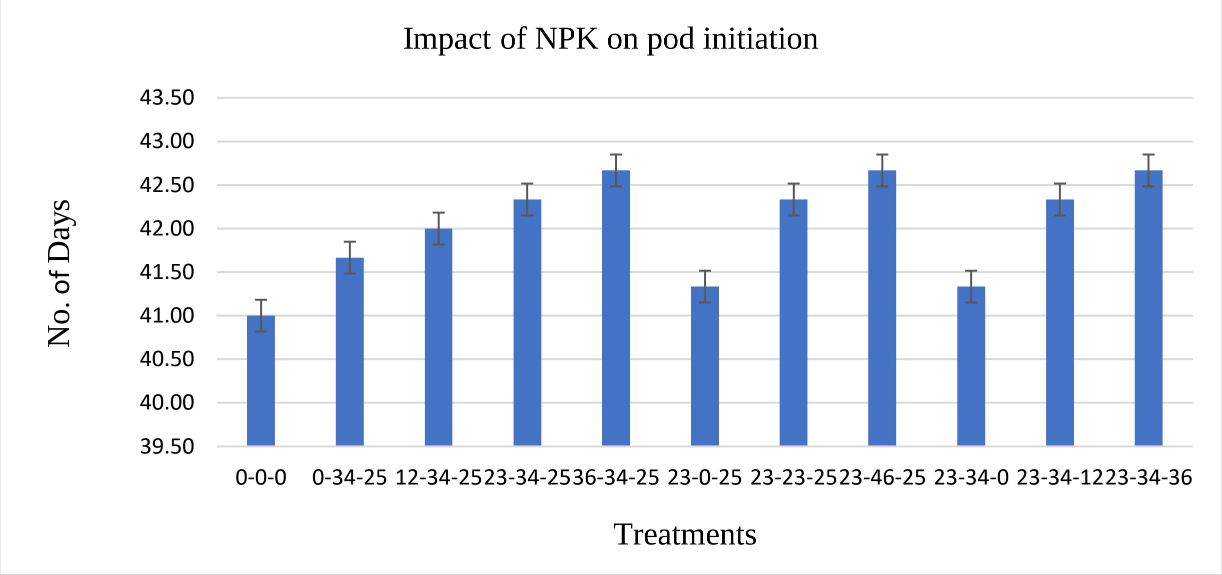
Impact of NPK on Timing of flower initiation and duration of flowering:

Different treatment combination of primary nutrients (N:P:K) had no significant differences on first flower initiation and duration of flowering (Fig.1). Numerically the earliest flower initiation (37.00 days) was observed in control treatment (no NPK added) while the late flowering (39.67 days) was recorded from 23:34:36 kg N:P:K ha^{-1}. In case of duration of flowering, the shortest duration (16.33 days) was found in 23:34:36 kg N:P:K ha^{-1} whereas the longest duration (21.67 days) was observed in 12:34:25 kg N:P:K ha^{-1}. (Fig. 1)

Fig:1 **Impact of NPK on Timing of flower initiation**



Impact of Different rates of NPK on days to first pod initiation and duration of pod formation: The data in figure 2 regarding first pod initiations and duration of pod initiation had no significant effect due to NPK levels. Data showed, the earliest pod initiation (41st day) was found in control treatment while the last pod initiation (43rdday) was recorded from 24:30:36 kg N:P:Kha^{-1}. In case of duration of pod initiation, the shortest duration (13.66 days) was found in control treatment whereas the longest duration (16thday) was recorded from 23:23:25 kg N:P:K ha^{-1}.



Plant height:

Collected data depicted that height of mungbean varied significantly with the different levels of NPK (Table 2). At harvest, the tallest plant (79.67 cm) was notedwhere36:34:25 kg N:P:K $ha^{-1}$was applied which was statistically similar to those in 23:34:25 kg N:P:K ha^{-1} and 23:34:25 kg N:P:K $ha^{-1}$and the shortest (61.33 cm) was recorded from control treatment.

Pods plant^{-1}:

Data regarding number of pods plant^{-1}as affected by different levels of NPK are shown in table. The maximum number of pods plant^{-1} (70.00) were recorded in 36:34:25kg N:P:K ha^{-1} which was statistically similar to that in 23:34:36 kg N:P:K ha^{-1} while the minimum number (55.33) was found for control treatment.

NPK Combinations	**Plant height (cm)**	**Pods plant^{-1}**	**1000 seed weight**	**Grain Yield**
0-0-0	61.33	55.33	23.00	560
0-34-25	71.67	62.33	26.27	732
12-34-25	72.33	64.00	26.90	971

23-34-25	76.00	64.67	27.37	995
36-34-25	79.67	70.00	31.00	1015
23-0-25	73.33	62.67	26.07	687
23-23-25	73.67	64.67	27.27	851
23-46-25	74.67	65.33	28.00	1001
23-34-0	74.00	62.67	26.17	821
23-34-12	74.33	64.67	27.53	956
23-34-36	77.67	68.33	30.57	1012
CV (%)	4.86	5.46	4.00	5.21
Significance level	*	*	*	*

1000-grain weight:

The data regarding 1000-grain weight were influenced significantly by NPK levels (Table 3). Fertilizer rate of 36:34:25 kg N:P:K ha^{-1} resulted maximum 1000-grain weight (30.57 g) which was significantly similar to 23:34:36 kg N:P:K ha^{-1} whereas control treatment (where no NPK was added) resulted the minimum 1000-grain weight (23.00 g).

Seed yield:

The statistical data elaborate that different nutrient combinations of NPK affected significantly the grain yield. The data presented in table showed that highest yield of 1015 kg ha^{-1} was obtained in T_5 that was statistically non-significant as compared with all other treatments except T_1, T_2 and T_6. Minimum yield was obtained in control i.e. 567 kg ha^{-1}. Results also indicate that T_4 is the best economical dose for this mung bean variety under Bahawalpur conditions. The former dose of fertilizer (23:34:36 NPK kg ha^{-1}) significantly improved 30.44 % yield as compared to control and performed better with respect to other treatments.

Conclusion

Mung bean (Vigna radiata L.) is an important pulse consumed all over the world, especially in Asian countries, and has a long history of usage as traditional medicine. It has been known to be an excellent source of protein, dietary fiber, minerals, vitamins, and significant amounts of bioactive compounds, including polyphenols, polysaccharides, and peptides, therefore, becoming a popular functional food in promoting good health. It is concluded that fertilizer dose(23:34:36

NPK kg ha^{-1}) improved the yield of mungbean upto 30.71 % under Bahawalpur climatic conditions. However different soils require diverse application of fertilizers. Different combinations of NPK have considerable influence on growth and yield of mungbean. From the above results and discussion of this experiment, it is concluded that proper dose of fertilizer improved the yield of mungbean (Bahwalpur Mung-17) under climatic conditions of Bahawalpur.

References

1. Chowdhury MAH, Hassan M (2013) Hand book of agricultural technology. Bangladesh Agricultural Research Council, Farmgate, Dhaka 230
2. Fuller DQ (2011) Finding plant domestication in the Indian subcontinent. Current Anthropology 52 (S4):S347-S362
3. Golkar P, Karimi S (2019) Safflower (Carthamus tinctorius L.) Breeding. In: Advances in Plant Breeding Strategies: Industrial and Food Crops. Springer, pp 537-575
4. Itelima J, Bang W, Onyimba I, Sila M, Egbere O (2018) Bio-fertilizers as key player in enhancing soil fertility and crop productivity: a review.
5. Keatinge J, Easdown W, Yang R, Chadha M, Shanmugasundaram S (2011) Overcoming chronic malnutrition in a future warming world: the key importance of mungbean and vegetable soybean. Euphytica 180 (1):129-141
6. Kibite S, Evans L (1984) Causes of negative correlations between grain yield and grain protein concentration in common wheat. Euphytica 33 (3):801-810
7. Li L, Yang T, Liu R, Redden B, Maalouf F, Zong X (2017) Food legume production in China. The Crop Journal 5 (2):115-126
8. Liang J, He Z, Shi W (2020) Cotton/mung bean intercropping improves crop productivity, water use efficiency, nitrogen uptake, and economic benefits in the arid area of Northwest China. Agricultural Water Management 240:106277
9. Marmot MG, Stansfeld S, Patel C, North F, Head J, White I, Brunner E, Feeney A, Smith GD (1991) Health inequalities among British civil servants: the Whitehall II study. The Lancet 337 (8754):1387-1393
10. Mia MB, Shamsuddin Z (2010) Rhizobium as a crop enhancer and biofertilizer for increased cereal production. African journal of Biotechnology 9 (37):6001-6009
11. Naeem M, Iqbal J, Bakhsh M (2006) Comparative study of inorganic fertilizers and organic manures on yield and yield components of mungbean (Vigna radiat L.). J Agric Soc Sci 2 (4):227-229
12. Paler ALL, Alcantara CG (2021) Effect of Azolla (Azolla pinnata) as a bio-stimulant on nutrient uptake and yield of mungbean (Vigna radiata L.). Organic Agriculture 11 (3):469-475

13. Rani S, Schreinemachers P, Kuziyev B (2018) Mungbean as a catch crop for dryland systems in Pakistan and Uzbekistan: A situational analysis. Cogent Food & Agriculture 4 (1):1499241
14. Shen G, Zhang S, Liu X, Jiang Q, Ding W (2018) Soil acidification amendments change the rhizosphere bacterial community of tobacco in a bacterial wilt affected field. Applied microbiology and biotechnology 102 (22):9781-9791
15. Smýkal P, Coyne CJ, Ambrose MJ, Maxted N, Schaefer H, Blair MW, Berger J, Greene SL, Nelson MN, Besharat N (2015) Legume crops phylogeny and genetic diversity for science and breeding. Critical Reviews in Plant Sciences 34 (1-3):43-104
16. WIswAR DW, WEsT RL, Winkleman WN (1995) Fisheries investigation in Oruktalik Lagoon, Arctic National Wildlife Refuge, Alaska, 1986. US Fish and Wildlife Service, Fishery Resource Office,
17. Yin Z, Guo W, Xiao H, Liang J, Hao X, Dong N, Leng T, Wang Y, Wang Q, Yin F (2018) Nitrogen, phosphorus, and potassium fertilization to achieve expected yield and improve yield components of mung bean. PloS one 13 (10):e0206285