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Quantitative and qualitative traits of mungbean influenced by fertility levels and stress mitigating chemicals

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Abstract
A field experiment was carried out during the *kharif* of 2017 at Agronomy farm, S.K.N. College of Agriculture, Jobner in Jaipur district of Rajasthan to study the effect of fertility levels and stress mitigationg chemicals on growth and yield of mungbean comprising of sixteen treatment combinations comprising, four levels of fertility (control, 50% RDF, 75% RDF, 100% RDF and four stress mitigating chemicals i.e. control, salicylic acid @ 75 ppm at flower initiation and 7 days after first spray, 75 ppm salicylic acid + 2% urea at flower initiation and 500 ppm thiourea at flower initiation), evaluated in randomized block design and replicated three times. Among the different level of fertility, application of 75% were recorded significantly higher value of all the growth and yield attributing characters *viz*., plant height, dry matter/plant, number of pods/plant, seed yield, straw yield and biological yield. Among stress mitigating chemicals 500 ppm thiourea remaining at par with salicylic acid + 2% Urea significantly increased the plant height, dry matter accumulation/plant, number of pods/plant, seed, straw and biological yield, nitrogen concentration and their uptake over salicylic acid and control.

Keywords: Fertility level, thiourea, salicylic acid, yield

Introduction

Mungbean [*Vigna radiata* (L.) Wilczek] is a self pollinated leguminous crop; grown during *kharif* as well as summer season in arid and semi arid regions (Singh and Singh, 2018) [22]; more susceptible to water stress condition than many other grain legumes. It is an excellent source of protein (24.5%) with high quality lysine (460 mg/g N) and tryptophan (60 mg/g N) containing, 51% carbohydrate and 3% vitamins (Ihsan *et al*., 2013) [6]. The crop productivity is mainly influenced by soil fertility management. The initial soil fertility status and moisture availability conditions decided the dose of fertilizer. Mungbean is a legume crop; fix atmospheric nitrogen (58–109 kg ha^{-1}) by its effective root nodules through *Rhizobium* (Ali and Mahmoud, 2013) [2]. Starter dose of nitrogen required for initial crop growth and development. Application of higher dose of nitrogen may decrease number of nodule and nodule growth and leads to adversely affect the nitrogen fixation capacity. Phosphorus helps in better root growth and development and thereby making them more efficient in biological nitrogen fixation (BNF).

Pulse production affected by abiotic stresses mainly due to drought and high temperature (Traub *et al*. 2017) [27]. Severe moisture and high-temperature stress cause a substantial decline in crop yields through harmful impacts on the growth, physiology, and reproduction of plants (Traub *et al*. 2017) [27]. Drought may frequently occur during kharif season in the arid and semi arid regions from vegetative period to maturity, crops raised under rainfed condition are forced to mature under prevailing environmental conditions. Under such situation, there is no full advantage of fertilizer application. Hence, application of stress mitigating chemicals might prove beneficial in crop tolerance to adverse conditions. Application of agro-chemicals especially thiourea and salicylic acid which have great promise to minimize such stresses. Thiourea is a synthetic compound sulphydryl compound has important role in plant growth and physiological processes (stomatal closure, CO_2 assimilation, ion uptake, and transport, inhibition of ethylene biosynthesis, transpiration, stress tolerance, membrane permeability, and photosynthesis) that influences overall plant growth, particularly under stress conditions (Salehi, 2011) [18], bringing marked biological activity in plants (Waqas *et al*., 2019) [29]. Seed priming, foliar spray, and soil application of thiourea stimulate defence mechanisms in plants under abiotic stress conditions and modulate photosynthesis, nitrogen metabolism, proline metabolism, and plant water relations during different plant developmental stages (Waqas *et al.*, 2019) [29]. Thiourea contains two functional groups, "thiol" plays an important role in oxidative stress while "imino" group fulfils the nitrogen requirement in stressed plants (Akladious 2014) [1]. Salicylic acid (SA) is a naturally occurring plant hormone performing as an important signalling molecule which adds to tolerance against abiotic stresses. It plays a vital role in plant growth, ion uptake and transport; involved in endogenous signalling to trigger plant defense against pathogens; an increased CO_2 assimilation, photosynthetic rate and increased mineral uptake by the stressed plant under SA treatment.

Materials and Methods

Field experimentation site, climate and weather conditions

The experiment was laid out at Agronomy farm, S.K.N. College of Agriculture, Jobner. Geographically, Jobner is at 26^0 05' North latitude, 75^0 28' East longitude and at an altitude of 427 metres above mean sea level. The area falls in agro-climatic zone-III a (Semi-arid Eastern Plain Zone) of Rajasthan. The average annual rainfall varies from 250 mm to 300 mm. During summer, temperature may go as high as 46^0C while in winter, it may fall as low as -1.5 ^{0}C. The mean weekly weather parameters during crop duration recorded at the college meteorological observatory. The rainfall during crop season received of 147 mm. The mean daily maximum and minimum temperatures recorded between 29.3 to 36.7 ^{0}C and 18.3 to 26.5 ^{0}C, respectively. Similarly, mean daily relative humidity ranged between 36 to 82 per cent.

Soil of the experimental field

The soil samples from 0-30 cm depth were taken from five random spots of the experimental field and subjected to mechanical, physical and chemical analysis. The results of these analyses along with methods used for determination are presented in table 1. The experimental field was loamy sand in texture, alkaline in reaction, poor in organic carbon, low in available nitrogen and medium in phosphorus and potassium content.

Table 1: Physical and chemical properties experimental field

Particulars	Values obtained	Method adopted and references
Textural class	Loamy sand	International pipette method (Piper, 1950) [5]
Bulk density (Mg/m^3)	1.53	Method No. 30 USDA Hand Book No. 60 (Richards, 1954) [17]
Particle density (Mg/m^3)	2.54	Method No.39 USDA Hand Book No.60 (Richards, 1954) [17]
Available N (kg/ha)	128.3	Alkaline permanganate method (Subbiah and Asija, 1956) [25]
Available P_2O_5 (kg/ha)	16.23	Olsen's method (Olsen *et al.*, 1954) [14]
Available K_2O (kg/ha)	154.26	Flame photometric method (Metson, 1956) [13]
Organic carbon (%)	0.18	Rapid titration method (Walkley and Black, 1947) [28]

Applied treatment details and crop management

The experiment was laid out using factorial randomized block design with three replications (total 16 treatment combinations). The applied treatments comprising of four fertility levels *i.e.* control (F_0), 50% RDF (F_1), 75% RDF (F_2), 100% RDF (F_3) and stress mitigating chemicals i.e. control (S_0), SA @ 75 ppm at flower initiation and 7 days after first spray (S_1), 75 ppm SA + 2% urea at flower initiation (S_2) and 500 ppm thiourea (S_3) at flower initiation. The mungbean was sown on 6th July 2017 in plot size of 4 m x 3.6 m with seed rate of 15-20 kg ha^{-1}. Fertilizers were applied as per treatment through diammonium phosphate (DAP) containing 46% P_2O_5 and 18% N and urea containing 46% N at the time of sowing as per treatment. Thiourea and salicylic acid treatments were applied as foliar spray with 500 liter water per hactare.

Observation of growth and yield attributes

Five plants were selected randomly from each plot; plant height was measured from base of the each plant to the tip of main shoot and worked out the mean plant height (cm). The plant from one metre row length were uprooted from sample rows of each plot and remove of root portion than the samples were first air dried for some days and finally dried in an electric oven at 70^0C till constant weight. The weight was recorded and expressed as average dry matter per plant (g). total number of pods of the five plants already selected were counted and mean value for number of pods per plant was calculated.The produce of each plot was weighed separately in kg per plot and then converted to seed yield in kg/ha. Straw yield (kg/ha) was obtained by subtracting the seed yield (kg/ha) from biological yield (kg/ha). Harvest index was calculated by using the formula given by Singh and Stoskopf (1971) [20].

Analysis of nitrogen concentration and its uptake

Estimation of nitrogen was done by colorimetric method (Snell and Snell, 1949) [24]. The uptake of nitrogen by crop was calculated using following formula:

$$\text{N uptake (kg/ha)} = \frac{\text{\% N in seed/straw x seed yield/straw yield (kg/ha)}}{100}$$

Data and Regression analysis

The data were statistically analysed by fisher's analysis of variance technique (Fisher, 1950) [4]. the regression coefficients were calculated by using method given by Snedecor and Cochran (1968) [23].

Results and Discussion

Effect on quantitative traits

The quantitative traits i.e. plant height, dry matter accumulation and numbers of pods per plant were significantly affected by fertility levels over control (Table 2). Highest plant height was recorded under application of 100% RDF at harvest (58.23 cm), which was significantly higher over 50% RDF and control but remained at par with 75% RDF. Application of 75% RDF increased the plant height by 16.52 per cent over control. Respective increase in dry matter of crop was 20.93%. The application of fertility levels up to 75% RDF recorded significantly higher number of pods per plant (20.27) over preceding fertility levels but remained at par with 100% RDF (20.48). The per cent increase in number of pods/plant due to 75% RDF was 25.85 and 6.06 over control and 50% RDF, respectively. The increase in these traits due to Optimum availability of nitrogen which enhance amount of growth substances and naturally occurring phytohormones, cell number and cell size, accelerates photosynthetic rate leading to better growth in terms of height and dry matter accumulation. Thus Similarly, increased supply of available phosphorus plays an important role in the conservation and transfer of energy in the metabolic reactions of living cells including biological energy transformations. Phosphorus also improves nodulation and nitrogen fixation by supplying assimilates to the roots resulted in vigorous growth of plants. The present investigation is in conformity with those of Choudhary and Yadav (2011) [3] in cowpea and Singh *et al.* (2017) [21] in mungbean.

Foliar applicaton of stress mitigating chemicals significantly increased plant height, dry matter accumulation and number of pods per plant over control and SA application (Table 2). Maximum plant height was recorded with foliar application of 500 ppm thiourea (59.05 cm) which remaining at par with 75 ppm SA + 2% Urea (S_2). Both treatments significantly increased plant height over control (S_0) and sole application of SA (S_1) with the per cent increase of 18.51 and 9.68 at harvest. Application of thiourea (S_3) enhanced the dry matter accumulation significantly over control and SA with the per cent increase of 16.80 and 8.94 at harvest, respectively. This treatment also recorded the maximum number of pods/plant (19.97) and proved superior to control. Thiourea improved photosynthetic efficiency, other physiological processes, alleviating abiotic stress, and increased dry matter partitioning. Thus, these favourable influences of thiourea brought significant improvement in plant height, dry matter accumulation and number of pods per plant. Similar results were also reported by Ghanshyam and Pareek (2009) [5] in mothbean and Talukdar (2014) [26] in mungbean. The increase in growth parameters due to SA may be attributed to the enhanced physiological activities like cell division, cell elongation, photosynthesis and translocation of nutrients and photosynthates. Superiority of SA + 2% Urea (S_2) might be due to synergistic action of urea with physiological and biochemical reactions, Hence SA + 2% Urea proved as good as thiourea and superior to SA alone.

Table 2: Effect of fertility levels and stress mitigating chemicals on quantitative traits

Treatments	Plant height (cm) at harvest	Dry matter accumulation at harvest (g/plant)	Number of pods/plant
Fertility levels			
Control	49.36	9.19	16.1
50% RDF	53.45	10.4	19.11
75% RDF	57.52	11.12	20.27
100% RDF	58.23	11.5	20.48
S.Em+	1.29	0.2	0.36
CD (P = 0.05)	3.77	0.64	1.11
Stress mitigating chemicals			
Control	49.78	9.67	17.42
SA @ 75 ppm at flower initiation and 7 days after first spray	53.79	10.37	19.09
SA @ 75 ppm + 2% Urea at flower initiation	55.99	10.87	19.48
Thiourea @ 500 ppm at flowering initiation	59.05	11.3	19.97
S.Em+	1.29	0.2	0.36
CD (P = 0.05)	3.77	0.64	1.11

Effect on seed, straw and biological yield

Higher seed (1077 kg/ha), straw (2279 kg/ha) and biological yield (3356 kg/ha) was recorded with application of 75% RDF which was higher seed yield by 14.57 and 44.95 per cent, straw yield by 7.24 and 22.06 per cent and biological yield by 9.49 and 28.58 per cent as compared to 50% RDF and control, respectively (Table 3). Increase in fertilizer dose beyond 75% RDF failed to improve the seed yield of mungbean appreciably. Hence, 75% RDF was the most effective dose for these yields. Application of varying fertility levels at 50, 75 and 100% RDF enhanced the harvest index over control by 7.73, 12.76 and 14.55 per cent, respectively and remained at par amongst them. The increase in seed and straw yields might be due to better nutritional status of the crop in the soil, which was low in N and P and medium in K. the increased supply of NPK and their higher uptake by plants might have stimulated the rate of various physiological processes in plant and led to increased growth and yield parameters and ultimately resulted in increased seed and straw yields. The biological yield is a function of seed and straw yields. Thus, significant increase in biological yield with the application of N and P could be ascribed due to increased seed and straw yield. The results of present investigation are in line with those of Karwasra *et al.* (2006) [7], Mathur *et al.* (2007) [11] and Manoj *et al.* (2014) [10].

Foliar application of agro-chemicals brought about perceptible improvement in seed, straw and biological yield of mungbean. Thiourea and SA + 2% Urea were at par with each other and proved superior to SA alone and water spray in respect to these yield. The maximum seed yield (1048 kg/ha) was recorded with thiourea which was significantly higher by 7.04 and 22.14 per cent over SA (979 kg/ha) and control (858 kg/ha). The maximum straw yield was also recorded with thiourea and proved superior to SA alone and water spray by 5.27 and 15.47 per cent, respectively. Spray of stress mitigating chemicals (thiourea, 3324 kg/ha, SA + 2% urea, 3211 kg/ha and SA, 3141 kg/ha) significant increase in biological yield as compared to control (2829 kg/ha). Harvest index remained statistically unchanged due to foliar spray of stress mitigating chemicals. The increase in yield attributes and yield recorded with thiourea. It might be due to increased crop photosynthesis favoured by both improved photosynthetic efficiency and source to sink relationship. Also, enhanced plant height and dry matter accumulation resulting increased the straw and biological yield. Majeed *et al.* (2016) [9] and Matwa *et al.* (2017) [12] also reported the similar results.

Table 3: Effect of fertility levels and stress mitigating chemicals on seed, straw and biological yields and harvest index

Treatments	Yield (kg/ha)			Harvest index (%)
	Seed	Straw	Biological	
Fertility levels				
Control	743	1867	2610	28.44
50% RDF	940	2125	3065	30.64
75% RDF	1077	2279	3356	32.07
100% RDF	1133	2341	3474	32.58
S.Em+	23	40	63	0.74
CD (P = 0.05)	68	114	183	2.14
Stress mitigating chemicals				
Control	858	1971	2829	30.16
SA @ 75 ppm at flower initiation and 7 days after first spray	979	2162	3141	31.00
SA @ 75 ppm + 2% Urea at flower initiation	1008	2203	3211	31.22
Thiourea @ 500 ppm at flowering initiation	1048	2276	3324	31.36
S.Em+	23	40	63	0.74
CD (P = 0.05)	68	114	183	NS

Effect on Qualitative traits

Nitrogen content and uptake in seed and straw significantly increased due to different fertility levels as compared to control (Figure 1and 2). The significantly highest N content (4.01%) and its uptake (81.0 kg/ha) by seed was registered at 100% RDF. Similarly, application of 100% RDF recorded maximum nitrogen content (1.50%) and their uptake (35.3 kg/ha) in straw (Figure 3 and 4). It might be due to improved nutritional environment in the rhizosphere as well as in the plant system leading to enhanced translocation of N, P and K in plant parts. Since the nutrient uptake is a function of its content in crop plant and seed and straw yield of the crop. The increase in these parameters due to N and P fertilization led to an increased uptake of nutrients in the present study. These results are in cognizance with the findings of Sasode (2008) [19] and Rathore *et al.* (2010) [16]. Nitrogen concentration in seed and straw of mungbean was influenced significantly by stress mitigating chemicals over control. Foliar application of 500 ppm thiourea at flower initiation recorded the maximum nitrogen concentration (3.85%) and uptake (73.9 kg/ha) in seed and proved superior over rest of the treatments except SA+ 2% Urea. The similar trend was also observed with nitrogen concentration (1.43%) and uptake (32.9 kg/ha) in straw. Thiourea application might have helped in improvement of metabolic processes of plants and better growth and development, leading to greater absorption of nutrients from rhizosphere, it might be due to metabolic role of SH-group in root physiology and biochemistry. Thiourea creates better microbial population in soil which responsible to mobilize essential nutrients. These results are in close conformity with the findings of Lakhana *et al.* (2005) [8] and Yadav (2005) [30].

Regression study

The regression analysis revealed the relationship between seed yield was positive and linear with dry matter at harvest (R^2= 0.959), number of pods per plant (R^2 = 0.967) and nitrogen uptake by seed (R^2 = 0.974) as illustrated in figure 5,6 and 7).

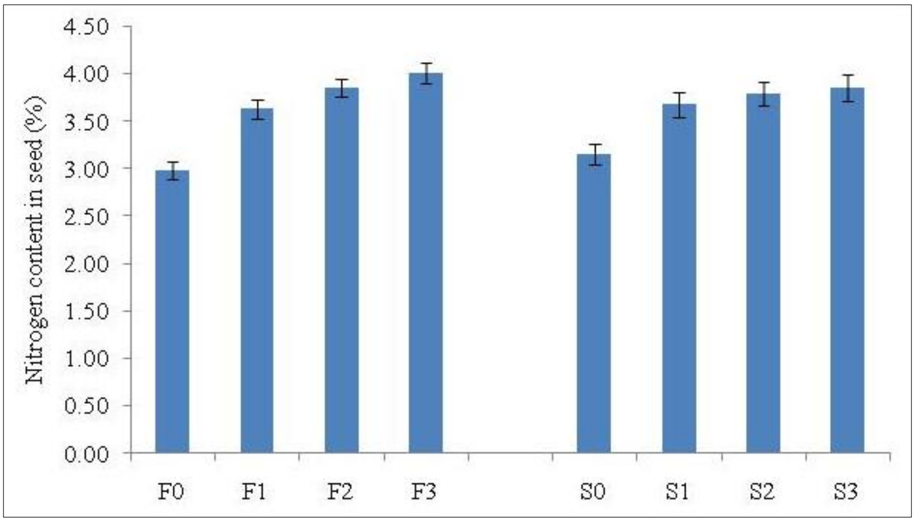

Fig 1: Effect of fertility levels and stress mitigating chemicals on nitrogen content (%) in seed. The vertical bars indicate standard errors. Treatments indicated by control (F_0), 50% RDF (F_1), 75% RDF (F_2), 100% RDF (F_3) and stress mitigating chemicals i.e. control (S_0), SA @ 75 ppm at flower initiation and 7 days after first spray (S_1), 75 ppm SA + 2% urea at flower initiation (S_2) and 500 ppm thiourea (S_3) at flower initiation.

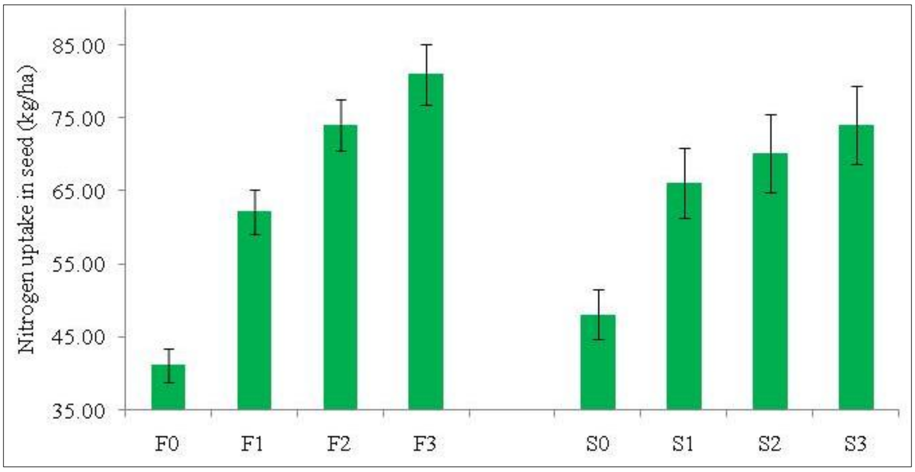

Fig 2: Effect of fertility levels and stress mitigating chemicals on nitrogen uptake (kg/ha) in seed. The vertical bars indicate standard errors. Treatments indicated by control (F_0), 50% RDF (F_1), 75% RDF (F_2), 100% RDF (F_3) and stress mitigating chemicals i.e. control (S_0), SA @ 75 ppm at flower initiation and 7 days after first spray (S_1), 75 ppm SA + 2% urea at flower initiation (S_2) and 500 ppm thiourea (S_3) at flower initiation.

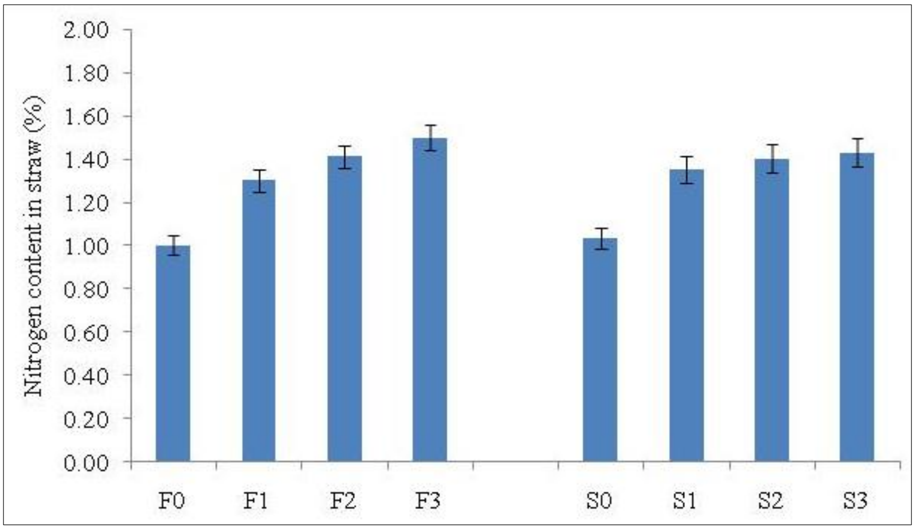

Fig 3: Effect of fertility levels and stress mitigating chemicals on nitrogen content (%) in straw. The vertical bars indicate standard errors. Treatments indicated by control (F_0), 50% RDF (F_1), 75% RDF (F_2), 100% RDF (F_3) and stress mitigating chemicals i.e. control (S_0), SA @ 75 ppm at flower initiation and 7 days after first spray (S_1), 75 ppm SA + 2% urea at flower initiation (S_2) and 500 ppm thiourea (S_3) at flower initiation.

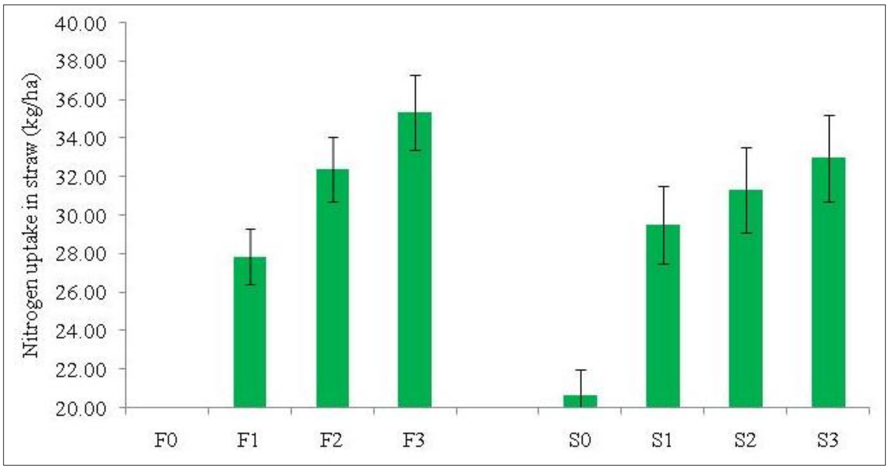

Fig 4: Effect of fertility levels and stress mitigating chemicals on nitrogen uptake (kg/ha) in straw. The vertical bars indicate standard errors. Treatments indicated by control (F_0), 50% RDF (F_1), 75% RDF (F_2), 100% RDF (F_3) and stress mitigating chemicals i.e. control (S_0), SA @ 75 ppm at flower initiation and 7 days after first spray (S_1), 75 ppm SA + 2% urea at flower initiation (S_2) and 500 ppm thiourea (S_3) at flower initiation.

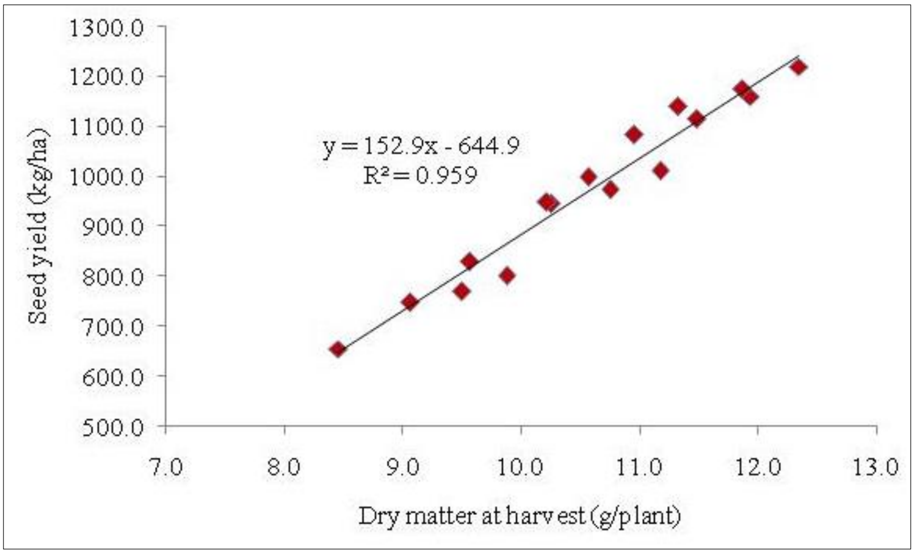

Fig 5: The linear regression between seed yield and dry matter accumulation (g/plant)

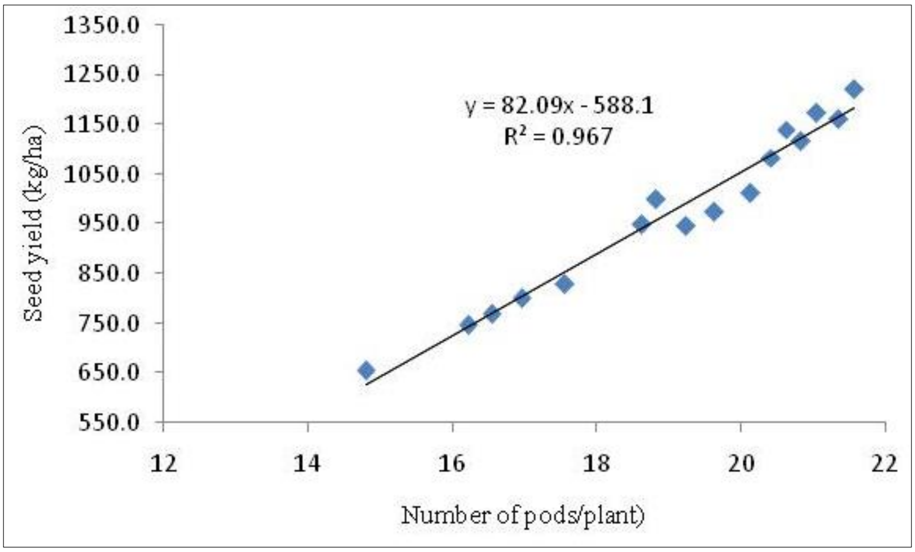

Fig 6: The linear regression between seed yield and number of pods/plant

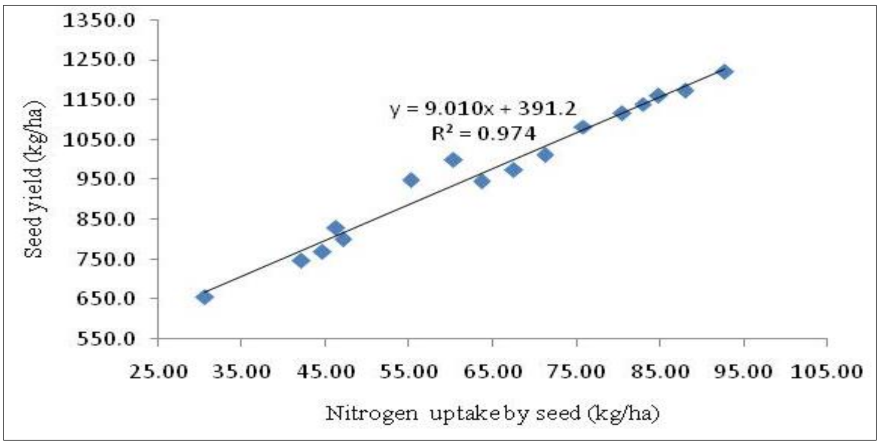

Fig 7: The linear regression between seed yield and nitrogen uptake by seed

Conclusion

Fertilizing the mungbean crop with 75% RDF brought about significantly higher plant height, dry matter accumulation, number of pods per plant, seed straw, and biological yield. However, highest nitrogen content and uptake by application of 100% RDF. Foliar application of either 500 ppm thiourea or 75 ppm SA + 2% urea at flower initiation is recommended to obtain significantly higher growth, yield attributes and seed yield, nitrogen content and uptake in mungbean seed and straw.

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