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Influence of Integrated Nutrient Management (INM) on agronomic and yield traits in Greengram *Vigna radiata* (L.) and Blackgram *Vigna mungo* (L.)

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Abstract
Balanced fertilizer application is one of the major components for enhancing crop productivity. High and / imbalanced use of nutrients has caused nutrient leaching from the soil resulted reduced yield of the crop. On the other hand applying of combination of organic and inorganic nutrients in balance has a direct effect on soil health and crop production. To understand this, conducted a field experiments with Greengram and Blackgram crops following integrated nutrient management approach in *rabi* season for two consecutive years (2018-19 and 2019-20) at RARS, Lam, Guntur. The Factorial Randomized Block Design (FRBD) with 18 treatment combinations *viz*., Factor A: T_1 -75% RDF, T_2 -100% RDF, T_3 -125%RDF; Factor B: 1. Control and 2. 5 t FYM ha^{-1}, Factor C: 1. *Rhizobium* 2. LNm16 and 3. *Rhizobium* +LNm16 and replicated thrice. The results revealed that application of 125% recommended dose of inorganic fertilizers reported significantly higher plant height (48.6 cm and 31.2 cm),branches plant^{-1} (3.3 and 4.0), pods plant^{-1}(26.0 and 26.3), seed pod^{-1} (11.3 and 6.5) and yield (1037 and 921 kg ha^{-1}) in greengram and blackgram respectively, between the organic manure applied and control plots, 5 t ha^{-1} FYM applied plots grabbed five percent additional grain yield and all the yield attributing characters were also significantly influenced by the FYM application. Among the biofertilizer treatments, combined inoculation of *rhizobium* + LNm 16 significantly influenced the higher plant height, branches plant^{-1}, pods plant^{-1}, seed pod^{-1}, test weight and seed yield (1023 and 894 kg ha^{-1}). Overall, the three-treatment combination has reported higher yield than the organic manure or bio fertilizer inoculation alone.

Keywords: Bio fertilizers, blackgram, greengram, inorganic fertilizers, organic manures

Introduction
In India major pulse crops grown are chickpea, pigeonpea, greengram, blackgram and lentil *etc*. These are highly nutritious, rich in dietary fibres, sugar and almost contain no fats (Kokani *et al.*, 2014) [9]. In India a large portion of greengram is used for human consumption in Indian cuisine, it comprises of all the major nutrients and can be eaten after sprouting of seeds by soaking it in water in fact the dried seeds are rich in phosphorus and nitrogen (of albumin and globulin), it is very rich in digestible protein contents involves proteins 26%, carbohydrates 56-60%, fat 1.5%, oil 1.5%, fibre 4.5% and phosphoric acid on the basis of dry weight consumed per capita globally. It holds ample amount of calorie contents 347 calories per 100 g (Amruta *et al.*, 2016) [1].

The area under total pulses 30.73 m ha with production of 27.3 m tonnes and an average productivity of 888 kg/ha in India. Both crops of greengram and blackgram are important pulse crops of India, as they are grown in an area of 4.85 and 4.84 m ha with total product ion of 2.65 and 2.73m tonnes and productivity of 546 and 564 kg/ha, respectively. In Andhra Pradesh, both crops cultivated in about 1.14 and 3.64 lakh hectares with an annual production of 0.86 and 3.60 lakh tonnes and average productivity of 752 and 990 kg /ha, respectively (Anonymous, 2022) [2]. Even though the national average productivity of pulses almost equal to state average productivity, but majority of pulse growing regions of AP, the productivity levels very low. The factors attributed for low yields of pulses in A P as compared to the National and world productivity are non- availability of quality seeds of improved and short duration varieties, growing of pulses under marginal and less fertile soil with low inputs and without proper

management of pests and diseases, growing of pulses under moisture stress, unscientific post- harvest practices and storage under unfavourable conditions. Hence, there is a scope for improving the production potential of this crop by integrated use of organic manures, inorganic manures and bio-fertilizers.

Greengram (*Vigna radiata* L. Wilczek) is one of the protein rich pulse crop grown in India. The lack of high productivity has contributed to food insecurity throughout the region and widespread malnutrition across India. Being a short duration crop, it its well in many intensive crop rotations, prevents soil erosion, fixes atmospheric nitrogen through symbiosis of Rhizobium and helps in improving soil fertility (Bansal, 2009) [3]. Pulses like greengram are generally grown in soils with low fertility status or with application of low quantities of organic and inorganic sources of plant nutrients, which has resulted in deterioration of soil health and productivity (Kumpawat, 2010) [10]. Organic manures provide a good substrate for the growth of soil microbes which helps to maintain a favourable nutritional balance and soil physical properties (Chaudhary *et al*, 2004) [4]. The organic acids produced during the process of decomposition of organic waste can exchange with adsorbed phosphorus and increase its availability to plants. Application of FYM increased the activity of acid and alkaline phosphatase, phosphodiesterase, inorganic pycophosphatase and dehydrogenase leading to faster hydrolysis of easter-bond phosphorus to plant available phosphorus (Dinesh *et al*, 2003) [5].

Blackgram (*Vigna mungo* L.) is a self-pollinated crop that grows to a height of 35-50 cm with yellow flowers and auxiliary inflorescences, and belongs to the family *Fabaceae*, subfamily *Papilionaceae*. It is distributed throughout Asia and it contains three times the protein content of cereals, in addition to being rich in carbohydrates, fats, amino acids, vitamins, and minerals. Blackgram is widely used in various culinary preparations. After pod removal, the green plants can be utilized as fodder. Black gram is one of the oldest and most prominent pulse crops in Asia (Kokani *et al*., 2014) [9]. The crop originated in India, with a secondary center of origin in Central Asia (Vavilov, 1951) [23], and later spread from India to Myanmar (Tateishi, 1996) [22] before expanding throughout Asia and other regions as a staple food legume. Archaeological evidence indicates that blackgram has been cultivated for approximately 4,500 years, with wild varieties discovered in Gujarat and the central peninsular regions of India (Fuller and Harvey, 2006) [6]. Its cultivation is prevalent in lowland tropics, subtropics, and up to 1,828 meters above sea level (Singh *et al*., 2017) [20]. In India, blackgram is also referred to as mash (Kaewwongwal *et al*., 2015) [8].

Blackgram is a significant legume crop, with India producing more than two-thirds of the world's supply (Saini and Jaiwal, 2002) [15]. It serves as food, feed, and industrial raw material, and ranks as the third most important pulse crop in India (Selvakumar *et al.*, 2012) [16]. Its adaptability allows cultivation across diverse agro-ecological zones. Blackgram is a staple food for approximately 900 million consumers and is vital for the nutrition of about one third of all undernourished children. Following the green revolution, increased cereal grain production led to a sharp decline in per capita production and availability of pulses, resulting in a record import of 4.0 million tonnes of pulses in 2012-13 (Singh *et al.*, 2017) [20].

The basic concept of integrated nutrient management is the supply of the required plant nutrients for sustaining the desired crop productivity with minimum deleterious effect on soil health environment. Integrated nutrient management intended for four major goals to be achieved by maintenance of soil fertility, to ensure sustainable agriculture, to prevent soil erosion and to reduce the expenditure on the cost of inorganic fertilizers (Sharma *et al*., 2004) [17]. Tillage, plant population, crop geometry, seed treatment (fungicides) and crop-specific bacterial cultures, sowing methods and time, nutrient and water (rainwater and irrigation) management, weed management and plant protection are major agronomic practices having impact on pulse productivity (Singh *et al*., 2012) [19]. Balanced fertilizer application is one of the important factors for increasing crop yield. Excess and imbalanced use of nutrients has caused nutrient leaching from the soil, reduced yield of the crop. Judicious combination of organic and inorganic nutrients has a direct effect on soil health and crop production. Integration of organic manures, inorganic fertilizers and bio-fertilizers has been found to be promising not only in maintaining higher productivity of crops and for providing stability in crop production, besides improving soil physical conditions (Verma *et al*., 2012) [24] with reduced cost of production. Therefore, the present investigation was taken up to assess the influence of organic, inorganic fertilizers and bio-fertilizers on growth and yield parameters of greengram and blackgram.

Materials and Methods

The experiment was conducted during two consecutive *rabi* season of 2018 and 2019 at Regional Agricultural Research Station (RARS), Acharya N.G.Ranga Agricultural University (ANGRAU), Lam, Guntur, India to study the effect of integrated crop management in Greengram and Blackgram. The experimental site is located at $16^0$18'N latitude, $80^0$29' E longitude and an altitude of 33 m above mean sea level (MSL). Soil of the experimental site was deep black clay loam in texture. The average temperature ranges from 18^0 to 32^0 C and the normal annual rainfall of the region is about 1113 mm. The initial soil was deep black clay loam in texture, low in organic carbon (0.48g kg^{-1}), available nitrogen (186.4 kg ha^{-1}), medium in available phosphorous (18. 8 kg ha^{-1}), available potassium (612.3 kg ha^{-1}) with pH (7.86) and electrical conductivity (EC) 0.48 dS m^{-1}.

The experiment was carried out in randomized block design with factorial concept and 18 treatment combinations *viz*., Factor A: 1.75% RDF, 2.100% RDF, 3.125%RDF; Factor B: Control and 5 t FYM ha^{-1}, Factor C: 1. *Rhizobium* 2.LNm16 and 3. *Rhizobium* + LNm16 and treatments were replicated thrice. Well decomposed farmyard manure (FYM) was applied @ 5 tonnes ha^{-1} for specific treatment combinations. Full dose of phosphorous (50 kg P_2O_5 ha^{-1}) and nitrogen (20 kg N ha^{-1}) in the form of SSP and Urea were applied as basal dose for specific inorganic treatment. *Rhizobium* and LNm16 were inoculated with the seeds just before sowing for the treatments with these specific combinations.

The crop was sown in first fortnight of October using genotypes of Greengram (IPM 2-14) and Blackgram (PU 31). Each treatment was accommodated in 6.0 m x4.0 m plot with row to row distance 30 cm and plant to plant 10 cm. Five plants from each plot were randomly selected for measuring plant height at harvest, no. of branch $plant^{-1}$, seeds pod^{-1} and pods $plant^{-1}$, while test weight/100 grain weight and grain yield were recorded after harvest. The data of both years were pooled together and statistically analysed by adopting appropriate method of standard analysis of variance (ANOVA) (Gomez and Gomez, 1984) [7].

Results and Discussion

Inorganic fertilizer impact on agronomic and yield traits

Productivity of greengram/blackgram crop is a function of

cumulative effect of various yield components, that are influenced by genetic make-up of variety, agronomic practices and environmental conditions. A glimpse of data presented in Table 1&2 revealed that plant height, number of branches plant^{-1}, pods plant^{-1} and test weight varied significantly due to difference in fertilizer levels. Plant growth of greengram and blackgram was significantly influenced by inorganic fertilizers. The data on plant height and branches plant^{-1} were recorded at harvest indicated that, treatments having 125% RDF recorded the highest plant height in greengram (48.6 cm) and blackgram (31.7 cm) than lower levels of fertilizers (75% RDF and 100% RDF). The number of branches plant^{-1} significantly enhanced up to the maximum level of fertilizer application (125% RDF) in both the crop *i.e* greengram (3.3) and blackgram (4.0) than that of lower levels of fertilizers, 75% RDF and 100% RDF. This is probably due to favourable function of nitrogen being a major structural constituent of cell helps in stimulating the cell division and cell enlargement, which increased plant height as well as number of branches. The results are in accordance with the findings of Patel *et al*. (2015) [12] and Reddy *et al*., (2011) [13] reported that the increased in number of branches could be possible because the application of organic and inorganic fertilizers along with bio-fertilizers due to enhancement of microbial activity in the rhizosphere which enables the roots for the better uptake of nutrients.

Similarly, all the yield attributes (except test weight of blackgram) of both crops were significantly higher with application of higher level of fertilizers *i.e*.125% RDF than remaining fertilizer levels (75% and 100% RDF). The response of fertilizers (N P K) on grain yield of greengram and blackgram were significantly increased from each level of fertilizer dose and the maximum grain yields (1037 kg ha^{-1} and 921 kg ha^{-1}, respectively) were realised at higher level of fertilizer application (125% RDF). This was largely attributed to better growth of plant which resulted in adequate supply of photosynthates for development of sink under higher level of inorganic fertilizer. Positive response in terms of yield attributes and yield of both the crops to application of inorganic fertilizers has also been reported by Singh *et al*., (2009) [18] and Patel (2012) [11].

Organic manures impact on agronomic and yield traits

Plots treated with farm yard manure @ 5 t ha^{-1} were recorded significantly higher plant growth, yield attributes and grain yield of greengram and blackgram (Table 1&2). The highest plant height (47.7 cm and 31.1 cm), number of branches plant^{-1} (3.1 and 3.9), number of pod plant^{-1} (25.4 and 25.4), number of seeds pod^{-1} (11.2 and 6.6), test weight (4.49 g and 4.61g) and seed yield (1005 kg ha^{-1} and 884 kg ha^{-1}) were registered with application of FYM@ 5 t ha^{-1} over control. An increase of 5 per cent higher grain yield was registered in FYM applied plots over without FYM application. This might be due to the favourable effect of well decomposed FYM on chemical, physical and biological properties of soil leads to easy availability of nutrients might have reflected in higher growth parameters, yield attributes and yield. Almost similar findings were also reported by Sahay *et al.* (2011) [14] in blackgram and Patel (2012) [11] in greengram.

Bio-fertilizer impact on agronomic and yield traits

Inoculation with bio-fertilizers did not significantly influence the plant height in greengram and blackgram (Table 1). All the yield attributing characters except test weight in blackgram influenced by inoculation of bio-fertilizers (*rhizobium*, LNm19 & rhizobium+LNm16). The higher values of yield components., the number of branches plant^{-1} (3.3 and 4.0), number of pods plant^{-1} (26.3 and 25.4), number of seeds pod^{-1} (11.2 and 6.6) and test weight (4.52 g and 4.52 g) were found with combined inoculation of both *rhizobium* +LNm16 than those inoculated separately (*rhizobium* and LNm16). The seed yield of both greengram (1025 kg ha^{-1}) and blackgram (894 kg ha^{-1}) also significantly higher with combined inoculation of *rhizobium* + LNm 16 over individual inoculation of either *rhizobium* (963 and 834 kg ha^{-1}) or LNm16 (948 and 855 kg ha^{-1}). This might be due to dual inoculation benefited the plants by fixing the atmospheric nitrogen and converting the insoluble phosphorus into available form. The enhanced availability of P favoured N fixation and rate of photosynthesis and consequently led to better plant growth and yield components. Almost similar findings were also reported by Sahay *et al.* (2011) [14] in blackgram and Patel (2012) [11] in greengram. The harvest index did not reach to the level of significance because of various bio-fertilizers treatments. The Positive response in terms of yield and yield attributes of greengram to integrated nutrient management have also been reported by Amruta *et al.* (2016) [1].

Combined effect of Inorganic fertilizers, organic manures and bio fertilizer on Yield

The comprehensive understanding of the treatment combinations highlights that even at lower fertilizer levels (75% RDF), combining FYM + dual inoculation substantially improved yield and similar findings were also reported by Singh *et al.* (2019) [21] (Fig.1). However, the best performance came from 125% RDF + FYM + biofertilizers in the both greengram and blackgram crops over the years.

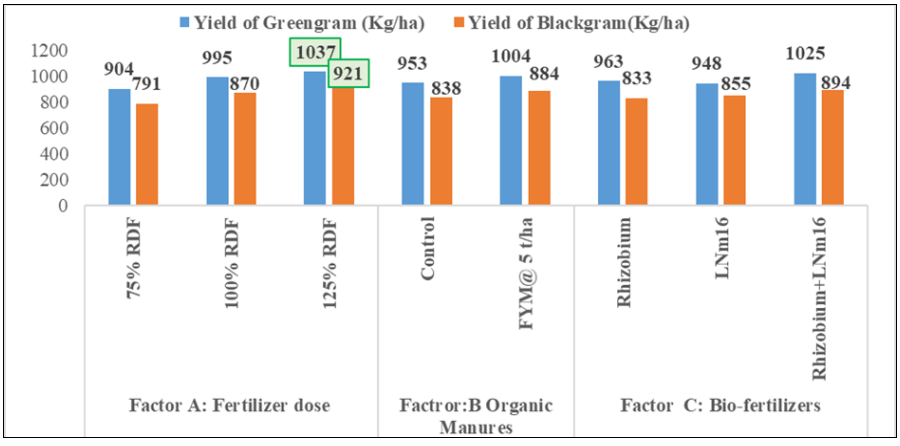

Fig 1: Yield of Greengram and Blackgram as influenced by various nutrient management practices

Table 1: Influence of integrated nutrient management on performance of *rabi* Greengram and Blackgram (Pooled data of 2018-19&2019-20)

Treatments	Greengram						Blackgram					
	Plant height (cm)	Branches plant^{-1}	Pods plant^{-1}	Seeds pod^{-1}	100 Seed wt. (g)	Grain yield (kg ha^{-1})	Plant height (cm)	Branches plant^{-1}	Pods plant^{-1}	Seeds pod^{-1}	100 Seed wt. (g)	Grain Yield (kg ha^{-1})
Factor A: Fertilizer dose												
1) 75% RDF	44.9	2.8	22.6	10.8	4.39	904	29.1	3.7	22.4	6.3	4.51	791
2)100% RDF	47.4	3.0	24.9	11.0	4.40	995	30.4	3.7	24.4	6.4	4.56	870
3)125% RDF	48.6	3.2	26.0	11.3	4.54	1037	31.7	4.0	26.3	6.5	4.57	921
Sem±	0.476	0.038	0.346	0.051	0.028	13.929	0.400	0.045	0.315	0.039	0.031	11.975
CD(0.05)	1.4	0.1	1.0	0.1	0.08	40	1.2	0.1	0.9	0.1	NS	34
Factor B: Organic Manure (FYM)												
1) Control	46.3	2.9	23.6	11.0	4.41	953	29.7	3.7	23.3	6.4	4.49	838
2) 5 t/ha	47.7	3.1	25.4	11.2	4.49	1005	31.1	3.9	25.4	6.6	4.61	884
Sem±	0.389	0.031	0.283	0.042	0.023	11.373	0.327	0.037	0.257	0.032	0.026	9.777
CD(0.05)	1.1	0.1	0.8	0.1	0.07	33	1.0	0.1	0.7	0.1	0.07	28
Factor C: Bio-fertilizers												
Rhizobium	46.5	2.7	24.0	11.0	4.37	963	30.1	3.6	23.2	6.3	4.59	833
LNm16	46.6	3.0	23.3	11.0	4.45	948	30.3	3.8	24.5	6.5	4.54	855
Rhizobium+LNm16	48.0	3.3	26.3	11.2	4.52	1025	30.8	4.0	25.4	6.6	4.52	894
Sem±	0.476	0.038	0.346	0.050	0.028	13.929	0.400	0.045	0.315	0.039	0.031	11.975
CD (0.05)	NS	0.1	1.0	0.1	0.08	40	NS	0.1	0.9	0.1	NS	34
Interaction												
AXB	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
AXC	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
BXC	NS	NS	NS	NS	0.12	NS	NS	0.2	NS	NS	NS	NS
AXBXC	NS	NS	NS	NS	0.20	NS	NS	NS	NS	NS	NS	NS
CV (%)	4.3	5.4	6.0	1.9	2.7	6.0	5.6	5.1	5.5	2.5	2.9	5.9

Conclusion

The collective effect of inorganic, organic, and biological sources highlight the need for integrated nutrient management in pulse production in vertosols of Krishna canal region. Among the three factors considered for the study Inorganic fertilizers provided immediate available nutrients to the crop, organic fertilizers enhanced soil organic matter and improved the soil physical properties that helps to increase water holding capacity and microbial inoculation amplifies and soil microbial activity which is crucial for legumes to maintain the healthy nodulation to fix atmospheric nitrogen. In this study results 125% RDF has reported higher yields highlighted the necessity to redefine the fertilizer dosages based on soil fertility and nutrient availability status. Further, this effect was coupled with the preceding crop nutrient uptake and nutrient availability during the rabi season at the crop root zone. Whereas indiscriminate use of chemical fertilizers may imbalance the soil physical properties, to reduce this effect it is necessary to integrate them with organic manures and microbial seed treatments to attain sustainable and balanced nutrient management approach. Hence, it's critically recommended that integrated and need based fertilizer application is necessary to attain higher yield with sustainable and healthy soil system.

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