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Effect of Inorganic and Organic Fertilizer on Growth Parameters of Black Gram (*Vigna mungo* L. Hepper) under Guava (*Psidium guajava*) based Agri-Horticultural System

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ABSTRACT

The yield of a particular crop mainly depends on the biological characters viz., plant height, root nodules per plant, number of trifoliate leaves per plant, number of primary branches per plant, secondary branches per plant, dry matter accumulation (g), etc. which are generally affected by the application of different inorganic and organic fertilizers. Then, it become an important task to evaluate the effects of different combinations of these fertilizers. In the present study, we are trying to test these effects on the said growth parameters under Agri-Horticultural system on black gram (*Vigna mungo* L. Hepper).The treatments were comprised of two levels of inorganic fertilizers i.e., NPK (20:40:20 and 30:50:30 kg per ha) and three level of organic manure (FYM, Vermicompost and Rhizobium inoculant) in factorial randomized block design (factorial-RBD), with 12 treatment combinations, each replicated three times. The average maximum plant height of black gram was found under the combination of Vermicompost + NPK (30:50:30 kg per ha) at 20, 45 and at harvest which was 19.75, 41.52, and 51.70 cm respectively. The lowest plant height was observed at all the stages of crop growth for the control group. The increment in growth was significant. It was possibly due to the synergistic effects of soil test based NPK, Vermicompost, FYM and Rhizobium inoculant. The combination of FYM, vermicompost, inorganic fertilizers and Rhizobium inoculation had pronounced on soil fertility that resulted in better vegetative growth in plant height, number of branches per plant, number of nodules per plant, straw yield. Thus, we would recommend to use NPK with vermicompost in order to get the optimum growth and yield of black gram in Agri-horticultural system.

Introduction

In developing countries like India, the land resources are shrinking due to continuous increase in population and it is very difficult to maintain present arable land (142.0 m/ha) and also the food security to the population. The country has the advantage of growing different horticultural crops in various agro-climatic zones. There is ample scope to exploit the interspaces of the fruit plantation during the initial 6-7 years by growing arable crops. Gill and Gangwar (1992) also stated that interspaces of custard apple and Aonlaorchards can be exploited by intercropping grain and fodder crops during initial years of establishment of fruittrees. There is great need to supplement or substitute chemical fertilizers with organic manures or to explore biological means to improve the soil health. The organic manures are not available in the Bidar region and whatever is available, the people use it as fire wood rather than to use it for soil fertility. Therefore, there is need to explore the potential of *Rhizobia* as legume inoculants under agro climatic conditions of the Bidar region. *Rhizobium* spp. invades the root hairs of legumes and result in the formation of nodules, where free air nitrogen is fixed. These bacteria, although present in most of the soils vary in number, effectiveness in nodulation and N-fixation.

It has been argued that usual native soil rhizobial populations are inadequate and are ineffective in biological nitrogen fixation. To ensure an optimum *rhizobial* population in the rhizosphere, seed inoculation of legumes with an efficient *rhizobial* strain is thus necessary. This helps improve nodulation, N_2 fixation solicit crop growth and yield of leguminous crops. *Rhizobia* is one of the dominant symbiotic nitrogen fixing bacteria with legumes but a number of factors including low number of *Rhizobia* and ineffective native *Rhizobia* lead to poor nodulation and nitrogen fixation in legumes. Legume and *Rhizobium* symbiosis contributes at least 90 x 106 metric tonnes of N per year all over the world (Subba Rao, 1983).

Many researchers carried out experiments on *rhizobium* inoculation with and without fertilizers on legume crops (Ashraf, 2003; Hayat *et al.,* 2004) and found increased nitrogen contents of seed, number of nodules, yield and yield components. Phosphorus is an important plant nutrient which is referred to as the “master key” element in crop production (Pierre,1938). It is associated with several vital functions like seed germination, cell division, flowering, fruiting, synthesis of fat, starch, and in almost every biochemical metabolic activity. It also induces root proliferation and nodulation.

Phosphorus has novel function of special importance in the process of energy storage and transfer. Most of the grain legumes have responded well due to its favourable effects on roots proliferating nodules development, bacterial activity and nitrogen fixation. Among the various factors responsible for maximization of yield of this crop, integration of NPK (20:40:20 and30:50:30 Kg per ha) with farm yard manure is most important factor, for maximizing the yield, it is essential that black gram should not suffer due to inadequate mineral nutrient especially nitrogen and phosphorus. Since chemical fertilizers are scare and costly, it is necessary to use them economically and in combination with organic fertilizers.

Materials and Methods

The field experiment was conducted during *kharif* season 2016 at Agricultural Research Farm Rajiv Gandhi South Campus, Banaras Hindu University, Barkachha, Mirzapur, Uttar Pradesh which is situated in Vindhyan region of the district of Mirzapur. Geographically, experimental site falls under the agro-climatic zone III A (semi-arid eastern plain) and located on 25^0 10' N latitude 82^0 37' E longitudes and an average height of 427 meters above mean sea level. Mirzapur falls in a belt of semi-arid to sub-humid climate. Soil samples were taken before actually conducting the experiment from a depth of 0-15 cm, taking all the possible precautions prescribed for soil sampling. The variety KU-300 was selected for the experimental work it isa resistant variety of black gram which was taken as a test crop. The experiment was laid out during rainy season (*Kharif*) of 2016 under 10 years old guava orchard which was planted in August, 2007 with the spacing of 7.0×7.0 meters. The experiment was conducted in factorial randomized block design set up with three levels of organic manure (viz., FYM, Vermicompost and

Rhizobium) and two fertilizer doses allocated as treatments (viz., N:P:K; 20:40:20 and 30:50:30 kg ha^{-1}) respectively. Fertilizer application was done according to the treatments. All the nutrients were applied as basal dose and the sources to N, P and K were Urea, DAP and MOP respectively. The treatment combinations used are given in the Table-0.

These treatment combinations were assigned to the experimental units randomly using random number table.

Results and Discussion

The following parameters were under consideration and their respective summaries are given below:

Plant height (cm)

The plant height as affected by different treatments and their responses were recorded at 20, 45, days after sowing (DAS) and at harvest. The results are tabulated in the Table-1 and it represent that the average maximum plant height of black gram recorded under the combination of Vermicompost + NPK (30:50:30 kg ha^{-1}) at 20, 45 and at harvest which were 19.75, 41.52, and 51.70 cm respectively. The lowest plant height was recorded at all the stages of crop growth in the control group. Increasing the levels of NPK (30:50:30 kg ha^{-1}) increases the plant height at each level of nutrient application at all the stages of crop growth except where organic manure is not used, i.e**.,** T_1(control group). The treatments T_{11} and T_{10} were at par with the control group at 45 DAS similarly, these treatments i.e., T_{11} and T_{10} treatments were also at par at harvest stage, it means there is no significant difference among them. The significant increment in plant height was recorded with the increasing rates of N, P, and K in combination with Vermicompost. Subsequent rate of elongation was slower particularly between 45 DAS and at harvest. Further, it was found that at 20,45 DAS and at harvest stage, T_{11}, T_{10} were at par with $T_1$and, also lowest height observed under T_1in which no inorganic and organic fertilizers applied it can easily be seen in the Figure-1.

Root nodules per plant

We have recorder the number of root nodules on the basis of per plant for two times i.e., 30 and 50 DAS. The number of root nodules at 50 DAS was significantly larger than the number of root nodules at 30 DAS. Treatments, T5, T6, T7, T8, T9, T10, T11 and T12 were at par among themselves, whereas the treatments T1, T2, T3 and T4 were also at par among themselves means there was no any significant difference among themselves. The number of root nodules in T10 and T11 were highest among all the treatments and were statistically significant from the treatments T1, T2, T3 and T4. Thus, we can say that the application of varying inorganic and organic fertilizers significantly enhances the number of root nodules per plant over the control group at 30 and 50 DAS of the cropping which is clearly visible in the Table-2. So, N:P:K (30:50:30) + FYM and N:P:K (30:50:30) + Vermicompost have significant and highest increment in the number of root nodules per plant over control and other treatment combinations, this is visible in the Figure-2.

Trifoliate leaves per plant

The number of trifoliate leaves per plant was recorded on 20, 45 DAS and at harvest after the sowing of black gram. At harvest the maximum number of trifoliate leaves was observed whereas the second highest number of trifoliate leaves was observed at 45 DAS and the minimum numbers of trifoliate leaves were observed at 20 DAS. It is evident from

Table-3 that number of functional trifoliate leaves per plant increased with the advancement of crop growth up to harvest, maximum increment was observed between 45 DAS and at harvest. There was significant variation in number of functional trifoliate leaves per plant within different combinations of treatment i.e., NPK (30:50:30 kg ha^{-1}) with vermicompost (T_{11}) and farmyard manure.

The maximum trifoliate leaves were observed at harvest stage of the crop growth under the treatments T10 and T11 which were N:P:K (30:50:30) + FYM and N:P:K (30:50:30) + Vermicompost, respectively. Application of NPK (30:50:30) with vermicompost was found to be the best treatment as it has produced the maximum number of functional trifoliate leaves among all the treatments including the control group which is also supported by the Figure-3. So, the treatment NPK (30:50:30) with vermicompost is preferred over all the treatment combinations.

Primary branches per plant

There was significant variation observed in the number of primary branches and these were influenced by different inorganic and organic fertilizer levels. Two observations were taken for the number of primary branches per plant viz., at 45 DAS and at harvest stage, throughout the crop growing period.

The number of primary branches per plant showed significant variations which are shown with the average number of primary branches in the Figure-4. The effect of different organic levels was found to be remarkable on the number of primary branches per plant at 45 DAS, and at harvest separately. Increasing fertilizer levels with organic manures showed significant improvement in the number of primary branches per plant at both the stages of crop growth.

The maximum number of primary branches per plant was observed with the combination of NPK (30:50:30 kg ha^{-1}) with FYM (i.e., T_{10})and NPK (30:50:30 kg ha^{-1}) with vermicompost (i.e., T_{11}) at all the stages of growth. The treatment NPK (30:50:30 kg ha^{-1}) with vermicompost and NPK (30:50:30 kg ha^{-1}) with FYM were significantly different from the control group**.** The result clearly revealed that the number of primary branches per plant of black gram was significantly increased with dual treatment of NPK (30:50:30 kg ha^{-1}) with vermicompost over the control and all other remaining treatments.

Secondary branches per plant

The number of secondary branches was recorder for two times i.e., 45 DAS and at harvest, in the whole crop growing period. There is much more variation among all the treatments and it was found that the treatment T_{10} and T_{11} were significantly different from all the rest of the treatments. The same is quite evident from the data presented in the Table-5 and also depicted graphically in the Figure-5.

The number of secondary branches per plant was increased with the advancement of crop growth however the maximum number of secondary branches was observed during 45 DAS to harvest. Maximum number of secondary branches was found to the treatments NPK (30:50:30 kg ha^{-1}) with FYM (i.e., T_{10}) and NPK (30:50:30 kg ha^{-1}) with vermicompost (T_{11}) which were significantly different from the control group.

Both the treatments were at par between themselves but significantly different from the control group it can be seen from the Figure-5. To get the optimum number of secondary branches we recommend to use NPK (30:50:30 kg ha^{-1}) with FYM or NPK (30:50:30 kg ha^{-1}) with vermicompost.

Table.1 Effects of inorganic and organic fertilizers on plant height of black gram

Treatment	Average Plant Height (cm)		
	20 DAS	45 DAS	At Harvest
T_1. I_0 O_0	14.51	30.35	37.79
T_2. I_0 O_1	16.73	35.00	43.58
T_3. I_0 O_2	17.78	37.20	46.31
T_4. I_0 O_3	15.66	32.76	40.79
T_5. I_1 O_0	17.19	36.14	45.00
T_6. I_1 O_1	18.42	38.72	48.22
T_7. I_1 O_2	18.79	39.50	49.19
T_8. I_1 O_3	18.93	39.80	49.56
T_9. I_2 O_0	17.48	36.75	45.76
T_{10}. I_2 O_1	19.69	41.39	51.53
T_{11}. I_2 O_2	19.75	41.52	51.70
T_{12}. I_2 O_3	19.25	40.47	50.38
S Em(±)	0.27	0.57	0.74
CD (*p*=0.05)	0.80	1.68	2.09
C.V.	5.18	5.48	5.54

Table.2 Effects of inorganic and organic fertilizers on number of root nodules per plant of black gram

Treatment	Root Nodules per Plant	
	30 DAS	50 DAS
T_1. I_0 O_0	16.83	30.53
T_2. I_0 O_1	19.41	35.21
T_3. I_0 O_2	20.63	37.42
T_4. I_0 O_3	18.17	32.96
T_5. I_1 O_0	19.14	72.73
T_6. I_1 O_1	20.50	77.92
T_7. I_1 O_2	20.92	79.49
T_8. I_1 O_3	21.08	80.09
T_9. I_2 O_0	19.46	73.94
T_{10}. I_2 O_1	22.33	83.27
T_{11}. I_2 O_2	24.00	83.55
T_{12}. I_2 O_3	21.43	81.42
S Em(±)	0.27	1.03
CD (*p*=0.05)	0.80	3.02
C.V.	4.65	5.58

Table.3 Effects of inorganic and organic fertilizer on the number of trifoliate leaves per plant of black gram

Treatment	Average number of Trifoliate Leaves per Plant		
	20 DAS	45 DAS	At Harvest
T_1. $I_0 O_0$	2.29	9.59	12.77
T_2. $I_0 O_1$	2.65	11.06	14.72
T_3. $I_0 O_2$	2.81	11.76	15.65
T_4. $I_0 O_3$	2.48	10.36	13.78
T_5. $I_1 O_0$	2.74	11.43	15.21
T_6. $I_1 O_1$	2.93	12.25	16.30
T_7. $I_1 O_2$	2.99	12.49	16.63
T_8. $I_1 O_3$	3.01	12.59	16.75
T_9. $I_2 O_0$	2.78	11.62	15.47
T_{10}. $I_2 O_1$	3.13	13.09	17.42
T_{11}. $I_2 O_2$	3.14	13.13	17.47
T_{12}. $I_2 O_3$	3.06	12.80	17.03
S Em(±)	0.04	0.18	0.24
CD (p=0.05)	0.14	0.54	0.70
C.V.	5.86	5.40	5.30

Table.4 Effect of inorganic and organic fertilizer on number of primary branches per plant of black gram

Treatment	Primary branches per plant	
	45 DAS	At Harvest
T_1. $I_0 O_0$	2.39	3.88
T_2. $I_0 O_1$	2.75	4.48
T_3. $I_0 O_2$	2.93	4.76
T_4. $I_0 O_3$	2.58	4.19
T_5. $I_1 O_0$	3.09	5.03
T_6. $I_1 O_1$	3.31	5.39
T_7. $I_1 O_2$	3.38	5.49
T_8. $I_1 O_3$	3.23	5.26
T_9. $I_2 O_0$	3.14	5.11
T_{10}. $I_2 O_1$	3.54	5.76
T_{11}. $I_2 O_2$	3.55	5.78
T_{12}. $I_2 O_3$	3.46	5.63
S Em(±)	0.04	0.07
CD (p=0.05)	0.13	0.22
C.V.	5.11	5.11

Table.5 Effects of inorganic and organic fertilizer on secondary branches per plant of black gram

Treatment	Secondary branches per plant	
	45 DAS	At Harvest
T_1. $I_0 O_0$	2.16	4.43
T_2. $I_0 O_1$	2.50	5.11
T_3. $I_0 O_2$	2.65	5.43
T_4. $I_0 O_3$	2.34	4.79
T_5. $I_1 O_0$	2.57	5.26
T_6. $I_1 O_1$	2.75	5.63
T_7. $I_1 O_2$	2.81	5.75
T_8. $I_1 O_3$	2.83	5.79
T_9. $I_2 O_0$	2.61	5.35
T_{10}. $I_2 O_1$	2.94	6.02
T_{11}. $I_2 O_2$	2.95	6.04
T_{12}. $I_2 O_3$	2.88	5.89
S Em(±)	0.04	0.08
CD (p=0.05)	0.12	0.24
C.V.	5.30	5.30

Table.6 Effects of inorganic and organic fertilizers on dry matter accumulation per plant of black gram

Treatment	Dry Matter Accumulation (g per Plant)		
	20 DAS	45 DAS	At Harvest
T_1. $I_0 O_0$	0.35	2.63	3.30
T_2. $I_0 O_1$	0.40	3.04	3.80
T_3. $I_0 O_2$	0.42	3.23	4.04
T_4. $I_0 O_3$	0.37	2.84	3.56
T_5. $I_1 O_0$	0.41	3.02	4.80
T_6. $I_1 O_1$	0.44	3.24	5.15
T_7. $I_1 O_2$	0.45	3.30	5.25
T_8. $I_1 O_3$	0.45	3.33	5.29
T_9. $I_2 O_0$	0.42	3.07	4.89
T_{10}. $I_2 O_1$	0.47	3.60	5.50
T_{11}. $I_2 O_2$	0.47	3.73	5.52
T_{12}. $I_2 O_3$	0.46	3.38	5.38
S Em(±)	0.006	0.04	0.07
CD (p=0.05)	0.019	0.13	0.21
C.V.	5.30	4.84	5.35

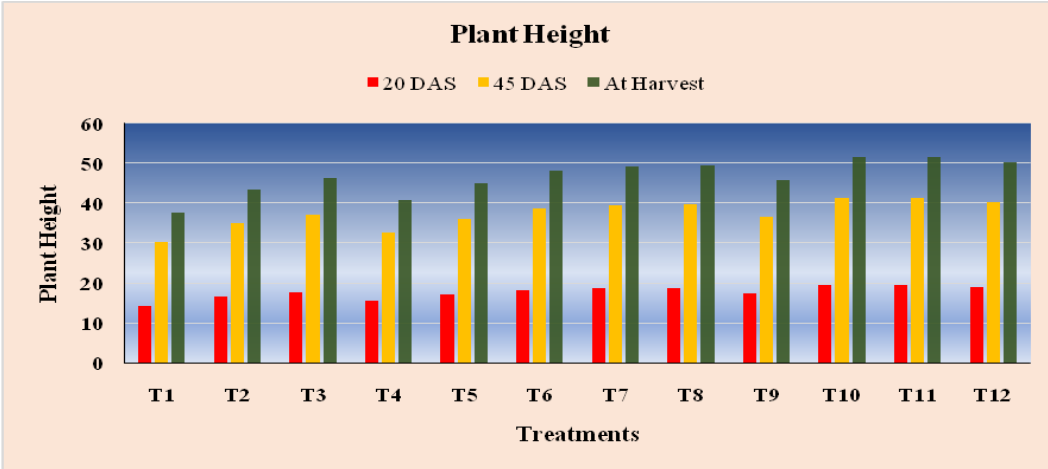

Figure.1 Average plant height observed at 20, 45 DAS and at Harvest

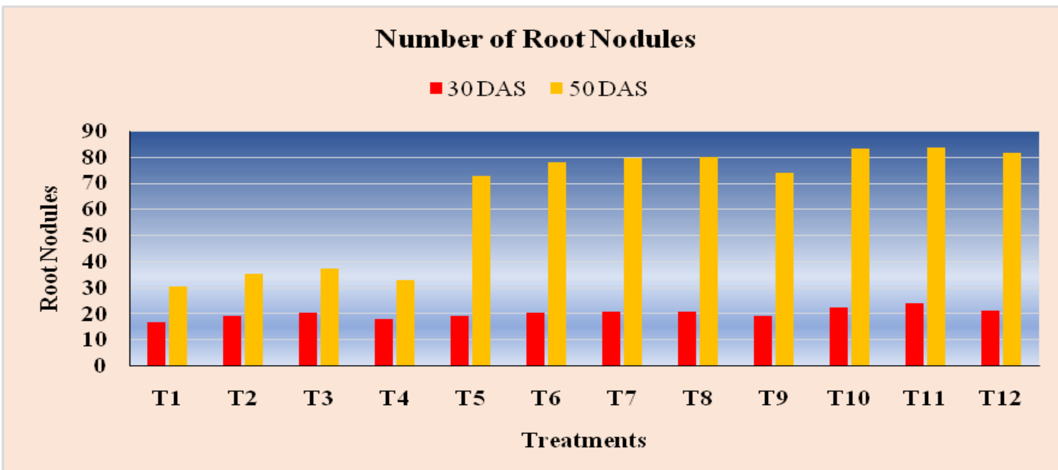

Figure.2 Average number of root nodules per plant observed at 30 and 50 DAS

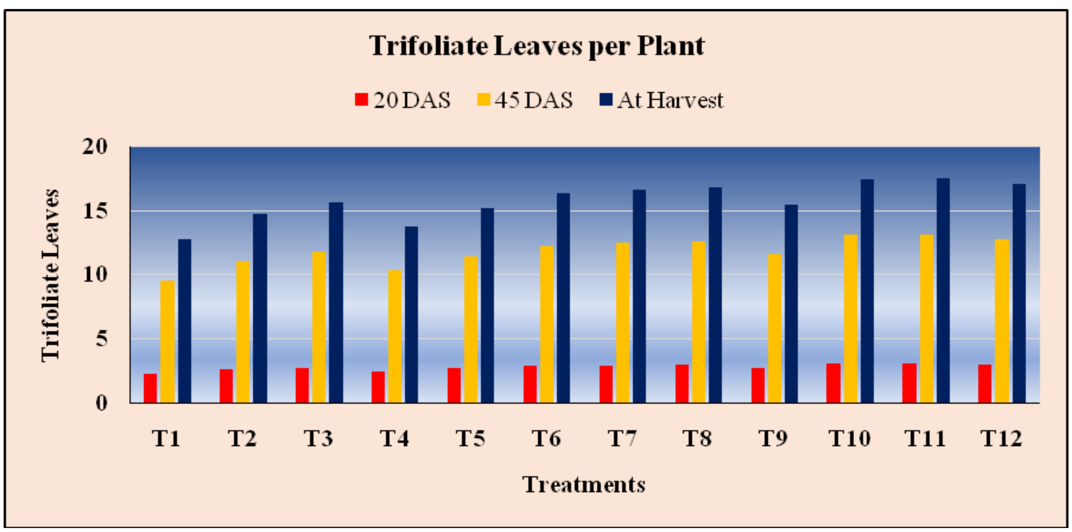

Figure.3 Average number of trifoliate leaves per plant

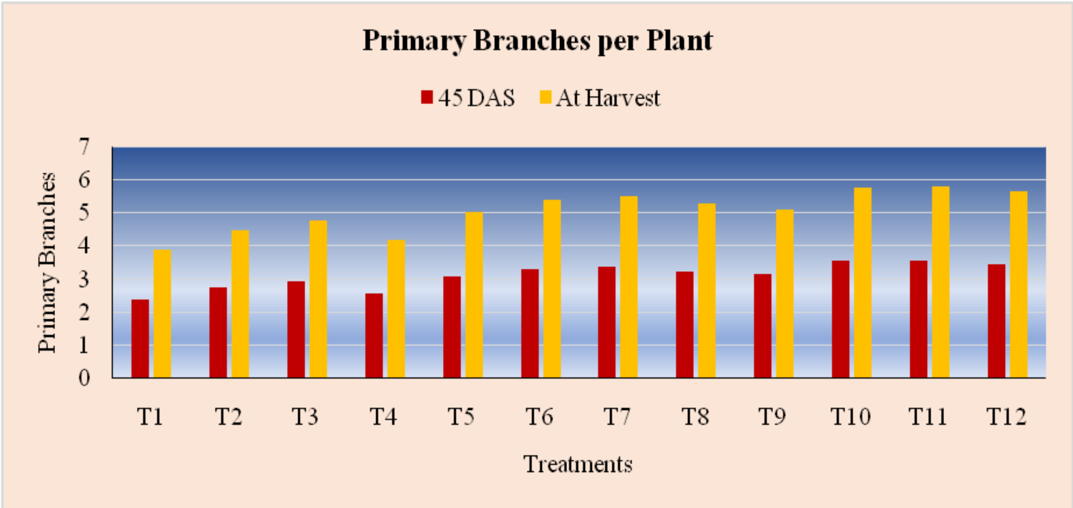

Figure.4 Average number of primary branches per plant

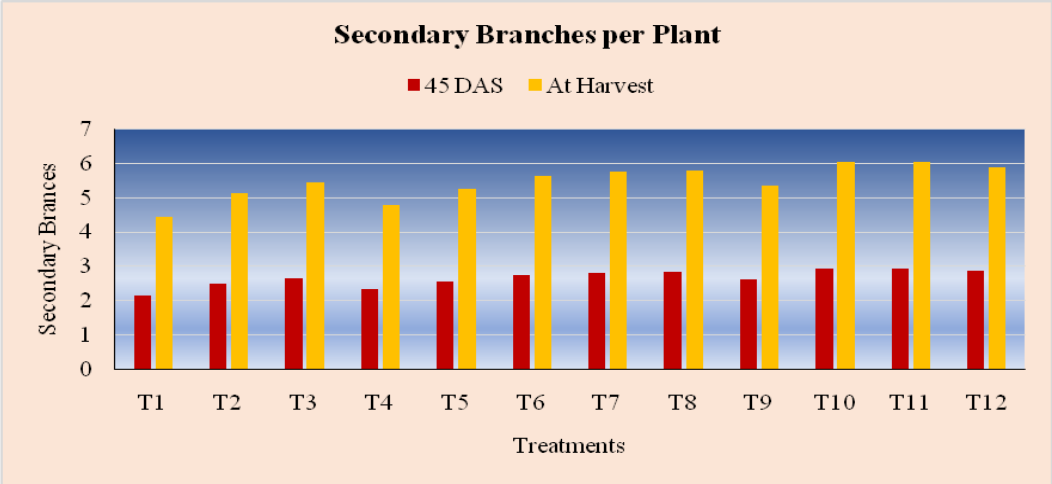

Figure.5 Average number of secondary branches per plant

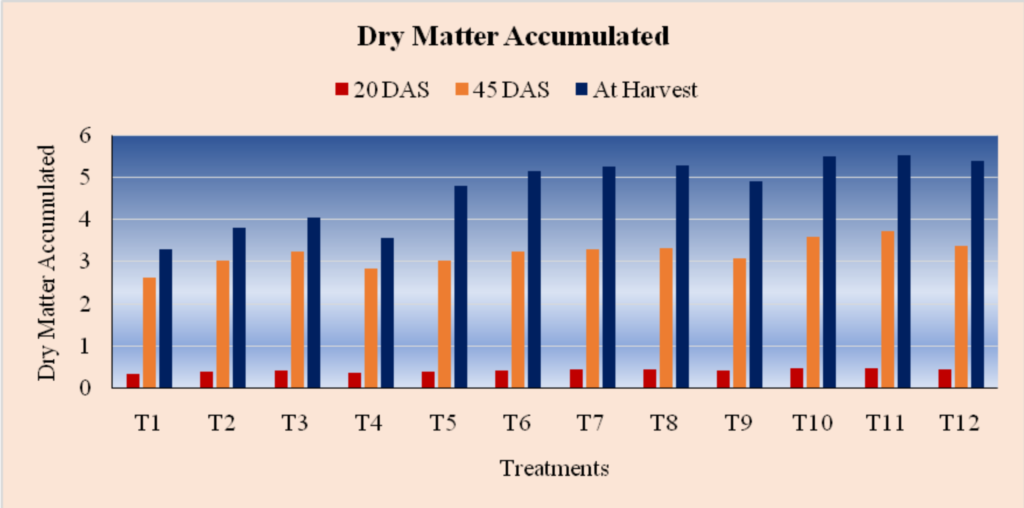

Figure.6 Dry matter accumulated (g) per plant

Dry matter accumulation (g per plant)

The dry matter accumulation (DMA) content in crop was significantly influenced by the treatment combinations viz., NPK (30:50:30 kg ha^{-1}) with FYM and NPK (30:50:30 kg ha^{-1}) with vermicompost throughout the crop growing period which are shown in the Table-6 and graphically in the Figure-6.It is clear that DMA significantly got affected by application of NPK (30:50:30 kg ha^{-1}) with FYM and that of vermicompost at 20, 45 DAS and at harvest stages, and found to be significantly higher than the control group. Maximum dry matter accumulation was observed for the treatment groups T_{10} and T_{11}, to obtain the same result we would recommend this group of treatments.

The results indicate that biological yields were significantly affected by the application of NPK (30:50:30 kg per hectare) with vermicompost and also significant increment in biological yield was observed in the treatment combination i.e., T_{11}as separate component as compared to the control group (no inorganic and organic fertilizer applied). The maximum biological yield was obtained with application of vermicompost with NPK (30:50:30 kg per hectare). The present results showed that the interaction of vermicompost and NPK level also found to be significant. The use of vermicompost and phosphatic bio-fertilizer, on the biological yield, revealed that the application of vermicompost @6 ton per hectare successively increased the utility of phosphatic biofertilizer, which resulted in a significant increment in biological yield also. The results revealed that vermicompost in combination with NPK level (30:50:30 kg per hectare) has significantly increased the yield, root nodulation, root development and nutrient availability which resulted in vigorous plant growth and more dry matter accumulation which lead to better flowering, fruiting, and pod formation and also helped in reducing in Phosphorous fixation by its effect and also solubilised the unavailable forms of Phosphorous leading to more removal of nutrients by the crop which is reflected better in growth parameters viz., number of pods per plant and grains per pod. It also increased the grain, straw and biological yields due to the cumulative effect of increased growth and yield parameters. More vegetative growth was observed in terms of dry matter production and branches per plant which was sites for the translocation of photosynthates and ultimately resulted in a greater number of pods per plant, grain per pod, pod length and test weight and also significantly benefitted by making ease in the availability of nutrients.

The increment in above parameters with the application of appropriate doses of nitrogen and phosphorus is important for effective removal and translocation of nutrients, especially phosphorus, which resulted in bold seed formation by increasing the size and weight of grains, there results are in close accordance with findings of Kumar *et al.,* (2003). The better growth of plant in terms of height and dry matter accumulation are most important factor in improving yield parameters and yield of black gram through better translocation of food reserves to sink. The different levels of phosphorus during this period regulate the carbohydrate accumulation ratio in the source leaves and the reproductive parts.

It also influences the stomatal resistance and activity of ribulose bi-phosphate and partitioning of photosynthates to sink development has led to a large number of pods per plant, grains per podand test weight. It also helped in stimulating the cell division and root elongation in meristematic tissues and constitutes ADP and ATP in plant, which plays an important role in energy storage. Due to increased dry matter and photosynthetic products with efficient translocation, plant produced more pods per plant with a greater number of grains per podand higher test weight and it is due to the combination of NPK (30:50:30 kg ha-1) with vermicompost, Rashmi *et al*., (2008) also observe the same effects as explained here.

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