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Reham Dawar
Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India

MD Giri
Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India

Ajit Kumar Meena
Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India

Gopal Patidar
Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India

Sandeep Rathod
Jawaharlal Nehru Krishi Vishwavidyalaya Jabalpur, Madhya Pradesh, India

Corresponding Author:
Reham Dawar
Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India

Effect of foliar application of gibberellic acid on growth, yield and economics of blackgram

Reham Dawar, MD Giri, Ajit Kumar Meena, Gopal Patidar and Sandeep Rathod

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Abstract
A field experiment was conducted at the research field of Pulses Research Unit, Washim Road, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (Maharashtra) during *Kharif* season of 2018, to study the effect of foliar application of gibberellic acid on growth, yield and economics of blackgram (*Vigna mungo* L.). In blackgram, 11 treatments comprising gibberellic acid management practices (application of 15, 30, 45 ppm GA_3 at flower and pod initiation stages and control) were tested. Results indicated that two applications of 30ppm GA_3 at flower and pod initiation stages recorded significantly number of pods/cluster, length of pod (cm),number of grains/pod, number of pods/plant, grain yield/plant (g), grain yield (kg/ha) and gross monetary returns than no application of the GA_3. The same treatment recorded higher rain water use efficiency and higher gross returns.

Keywords: Blackgram, foliar application, GA_3, rain water use efficiency (RUE)

Introduction

India is the major producer, consumer and exporter of pulses in the world. Being an economical source of protein, high fibre content, vitamins and minerals along with unique ability to restore soil health, pulses have assumed the role of universal remedy for sustainable production (Deol *et al.*, 2018) [7]. Pulses are important component to sustain agriculture production as they possess wide adaptability to fit into various cropping systems and being leguminous in nature have been known for their soil ameliorative effects. Although 28.1 million hectares of land in India is under pulse cultivation with annual production of 18.31 million tonnes representing 34.88 % of world area and 25.08 % of worlds pulse production (FAO, 2013) [8]. Yet, stagnant pulse production over the last two decades has resulted in reduced per capita pulse consumption from 60 gm capita^{-1}day^{-1} in 1950-51 to 32 gm capita^{-1}day^{-1}at present (Anonymous, 2018). Such reduced consumption is much lower than the actual recommendation of World Health Organization of 80 gm capita^{-1}day^{-1}. This has also led in an increment in annual import of pulses overall from 0.50 million tonnes to 1.80 million tonnes during the last 5 years, causing a reduction in the contribution of pulses in the national food basket from 17 % to 27% (Anonymous, 2018) [4].

Blackgram belongs to family *Leguminoseae*. Blackgram (*Vigna mungo* L.) is the important pulse crop of India cultivated over a wide range of agro-climatic zones of the country. This crop is grown in *Kharif* and *Rabi* seasons, however, maximum area is under *Kharif* cultivation where intercropping with sorghum, pearl millet, maize, cotton, castor, pigeonpea is very popular. Development of short duration, photo thermo insensitive and disease resistant varieties has led to its cultivation as a sole or intercrop during *Rabi* season in North India as a sole relay crop and in the rice fallows of the coastal peninsula. To make the nation pulse sufficient, productivity level of pulses, should be increased substantially to 1200 kg per ha by 2020 (Ali and Kumar, 2005) [3]. Plant growth regulators are known to improve physiological efficiency including photosynthetic ability of plant and offer significant role in realizing higher crop yields. The plant growth regulators are also known to enhance the source sink relationship and stimulate the translocation of photo assimilates, thereby increase the productivity. Assimilate translocation to reproductive sinks is vital for seed development. Seed set and filling can be limited by availability and utilization of assimilates (Asch *et al.*, 2005) [5]. The grain yield of blackgram crop was increased due to cumulative effect of yield attributing characters, enhanced photosynthetic efficiency and improvement in the capacity of the reproductive sinks to utilize the incoming assimilates due to the foliar application of GA_3 (Manjari 2018) [11].

With this background in view, the present investigation was planned with the following

Materials and Methods

The present experiment was conducted at the research field of Pulses Research Unit, Washim Road, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (Maharashtra) during *Kharif* season of 2018. The soil of experimental plot was clayey and slightly alkaline (pH 8.30), with available nitrogen (170kg/ha), phosphorus (21 kg/ha) and potassium (589.3 kg/ha) content. Geographically Akola is situated between $22^0 42$'N $77^0 02$'E and its mean height above sea level is 307.41m. It receives most of the rainfall from South-West monsoon, commencing from middle of June. The normal monsoon season precipitation approximates to about 731.6mm in 36 rainy days from the middle of June to September. The details of the crop season rainfall during the experimentation period are given in Table 1 and Fig. 1. For studying the effect of foliar application of gibberellic acid on growth, yield and economics of blackgram (*Vigna mungo* L.), randomized block design was used. The details of the treatments and symbols used are given in Table 2. In all, there were 11 treatments replicated three times. The experimental field was laid out in 33 unit plots, each plot measuring 10.80 m^2 (3.00m x 3.60m). There were twelve rows of blackgram crop in each plot and thirty plants in each row. One row of crop from both sides of lengthwise and breadth wise were left as guard rows. The net plot consisted of ten rows with twenty eight plants per row (2.80m x 3.00m). Seeds of blackgram variety PDKV- blackgold (AKU 10-1) were sown @ 15 kg/ ha (317390 plants/ ha) with the spacing of 30cm between rows and 10cm between plants on 24th June 2018. A fertilizer dose of 20 kg N, 40 kg P2O5 and 20 kg K2O/ ha through urea, single super phosphate and muriate of potash was applied at the time of sowing (basal application) to all the plots. Foliar application of gibberellic acid was done as per the treatments. For the foliar application of gibberellic acid a stock solution of 1000ppm was prepared by using 1.1g gibberellic acid technical (90%) along with promix (solvent) dissolved in distilled water and made the volume to 1000ml using volumetric flask and from this stock solution required amount of the gibberellic acid as per the treatments was utilized for foliar application (Table 2). Timely recommended plant-protection measures for blackgram crop were followed to save the crop from pests and diseases. The blackgram crop was harvested manually on 17^{th} september 2018. Different growth and yield components were recorded periodically. The data on various parameters recorded from experimental plots were statistically analyzed as suggested by Panse and Sukhatme (1995) [12] by using 'F' test at P=0.05

Table 1: Distribution of the rainfall during crop growth stages of blackgram

Sr. No.	MW	Period	Crop growth stage	Rainfall (mm)		% of Normal
				Normal (1971 - 2010)	Actual (2018)	
01	25-26	24^{th} June to 1^{st} July, 2018	Germination	90.5	194.1	214.48
02	27-29	2^{nd} July to 22^{nd} July, 2018	Vegetative	145.5	230.2	158.21
03	30	23^{rd} to 29^{th} July, 2018	Flowering	44.2	30.7	69.46
04	31-32	30^{th} July to 12^{th}August, 2018	Pod Initiation	109.2	08.0	7.33
05	33-36	13August to 9^{th} September, 2018	Pod Development	162.9	206.2	126.58
06	37-38	10^{th} to 17^{th} September, 2018	Maturity	43.5	62.4	143.45
			Total	595.8	731.6	122.79

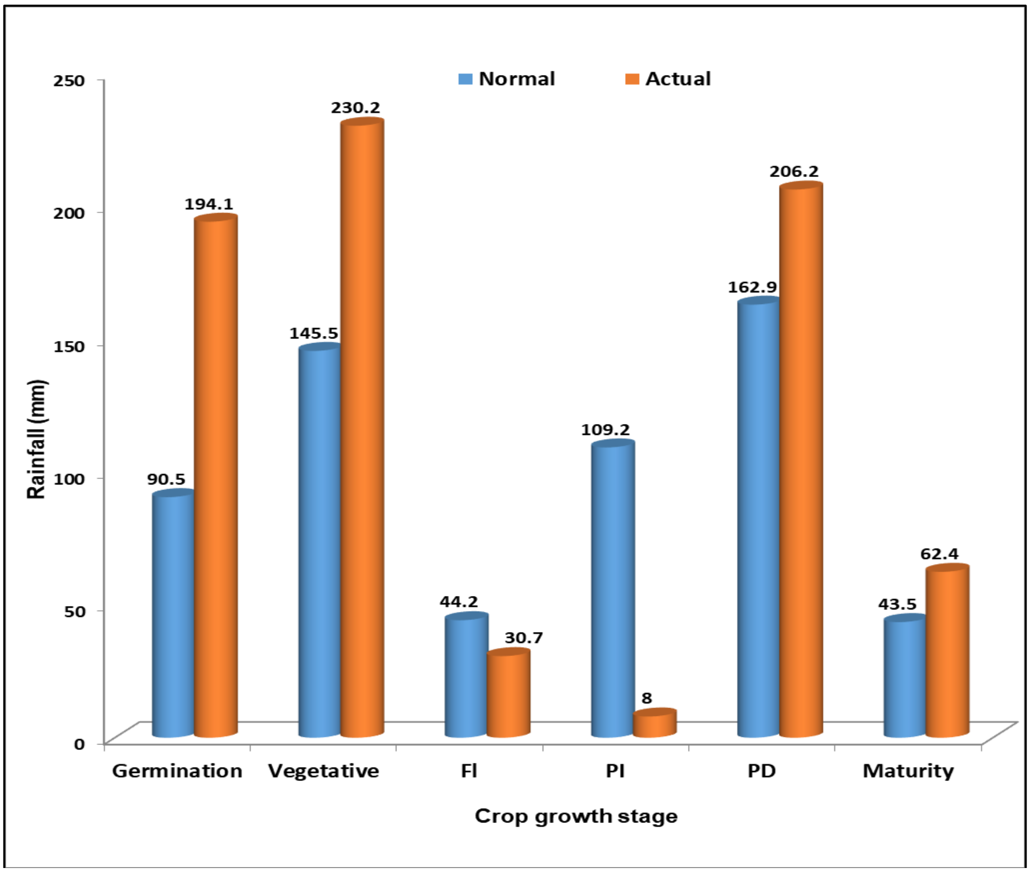

Fig 1: Distribution of the rainfall during the crop growth stages of blackgram

Table 2: Schedule of GA_3 application in various treatment

Symbol	Treatment	Number of GA_3 applications	Quantity of 1000ppm GA_3 stock solution utilized
T_1	Control (no application of GA_3)	Nil	Nil
T_2	Water spray at flower and pod initiation	Nil	Nil
T_3	Foliar application of 15 ppm GA_3 at flower initiation	01	15ml/ liter water
T_4	Foliar application of 30 ppm GA_3 at flower initiation	01	30ml/ liter water
T_5	Foliar application of 45 ppm GA_3 at flower initiation	01	45ml/ liter water
T_6	Foliar application of 15 ppm GA_3 at pod initiation	01	15ml/ liter water
T_7	Foliar application of 30 ppm GA_3 at pod initiation	01	30ml/ liter water
T_8	Foliar application of 45 ppm GA_3 at pod initiation	01	45ml/ liter water
T_9	Foliar application of 15 ppm GA_3 at flower & pod initiation	02	15ml/ liter water
T_{10}	Foliar application of 30 ppm GA_3 at flower & pod initiation	02	30ml/ liter water
T_{11}	Foliar application of 45 ppm GA_3 at flower & pod initiation	02	45ml/ liter water

Results and Discussion

Growth and yield parameters

Foliar application of GA_3 significantly influenced the blackgram plant height (cm), number of pods/cluster, length of pod (cm), number of grains/pod, number of pods/plant and grain yield/ plant (g). Two applications of 30 ppm GA_3 at flower and pod initiation stages (T10) recorded significantly higher number of pods/cluster, length of pod (cm), and grain yield/ plant. (Table 4). Two applications of 45 ppm GA_3 at flower initiation and at pod initiation stages (T11) recorded significantly higher plant height (cm) (Table 3).

Table 3: Effect of different treatments on plant height (cm) and number of branches plant^{-1} of blackgram

Treatments	Plant height (cm)			No. of branches/ plant		
	43 DAS	58 DAS	At harvest	43 DAS	58 DAS	At harvest
T_1: Control (No spray)	21.51	38.97	41.13	2.20	2.60	2.60
T_2: Water Spray at flower + pod initiation	20.80	38.58	41.67	2.20	2.60	2.60
T_3: 15 ppm GA_3 at flower initiation	22.49	39.09	41.88	2.33	3.00	3.00
T_4: 30 ppm GA_3 at flower initiation	24.49	40.86	44.25	2.60	3.07	3.07
T_5: 45 ppm GA_3 at flower initiation	24.55	39.59	46.07	2.87	3.07	3.07
T_6: 15 ppm GA_3 at pod initiation	20.27	36.67	40.71	2.13	2.87	2.87
T_7: 30 ppm GA_3 at pod initiation	20.07	38.35	41.05	2.20	3.00	3.00
T_8: 45 ppm GA_3 at pod initiation	20.13	36.67	41.41	2.20	2.87	2.87
T_9: 15 ppm GA_3 at flower + pod initiation	22.48	38.86	42.21	2.43	3.13	3.13
T_{10}: 30 ppm GA_3 at flower + pod initiation	24.61	42.73	46.51	2.40	3.73	3.73
T_{11}: 45 ppm GA_3 at flower + pod initiation	24.17	46.81	47.68	2.30	3.73	3.73
S.E. (m) $\pm$	1.24	1.36	1.73	0.12	0.26	0.26
CD (P=0.05)	NS	NS	5.06	NS	NS	NS
GM	22.32	39.74	43.14	2.35	3.06	3.06

The effect of foliar application of GA_3 on number of branches/plant and seed index in blackgram was found non-significant (Table 3). Improvement in growth parameters of blackgram crop is due to the foliar application of different concentrations of GA_3 over untreated (control) is possibly due to the beneficial effects of GA_3 on cell elongation and cell division, increase in photosynthetic activity and better food accumulation. The foliar application of GA_3 at flower initiation and pod initiation stages might have improved the reproductive development of blackgram crop and supported efficient translocation of photosynthates from source to sink. This might have significantly increased the number pods/ plant, grain mass and yield/plant. Similar results were observed by Uddin (2001) in greengram crop, Akter *et al.*, (2007) [2] in mustard crop, Giri *et al.* (2018) [9] in pigeonpea crop and Kumar *et al.* (2018) [10] in mungbean crop.

Table 4: Effect of different treatments on number of pods/ cluster, length of pod (cm), number of grains/ pod, number of pods plant^{-1}, grain yield plant^{-1} (g) and seed index (g) of blackgram

Treatments	No. of pods cluster^{-1}	Length of pod (cm)	No. of grains pod^{-1}	No. of pods plant^{-1}	Grain yield plant^{-1} (g)	Seed index (g)
T_1: Control (No spray)	3.93	4.55	5.86	23.80	6.60	4.50
T_2: Water Spray at flower + pod initiation	3.93	4.56	5.87	24.20	6.67	4.50
T_3: 15 ppm GA_3 at flower initiation	4.33	4.78	5.99	25.53	7.20	4.50
T_4: 30 ppm GA_3 at flower initiation	4.47	5.23	6.23	26.33	7.60	4.53
T_5: 45 ppm GA_3 at flower initiation	4.47	5.10	6.36	26.40	7.80	4.58
T_6: 15 ppm GA_3 at pod initiation	4.27	4.69	5.99	24.33	6.73	4.57
T_7: 30 ppm GA_3 at pod initiation	4.20	4.77	5.98	24.13	6.67	4.59
T_8: 45 ppm GA_3 at pod initiation	4.20	4.65	6.16	24.60	6.73	4.61
T_9: 15 ppm GA_3 at flower + pod initiation	4.53	5.17	6.62	28.27	8.13	4.61
T_{10}: 30 ppm GA_3 at flower + pod initiation	4.63	5.25	6.87	28.80	8.40	4.61
T_{11}: 45 ppm GA_3 at flower + pod initiation	4.53	5.15	6.60	28.33	8.27	4.61
S.E. (m) $\pm$	0.15	0.15	0.14	1.16	0.37	0.11
CD (P=0.05)	0.43	0.43	0.42	3.40	1.09	NS
GM	4.32	4.90	6.23	25.88	7.35	4.57

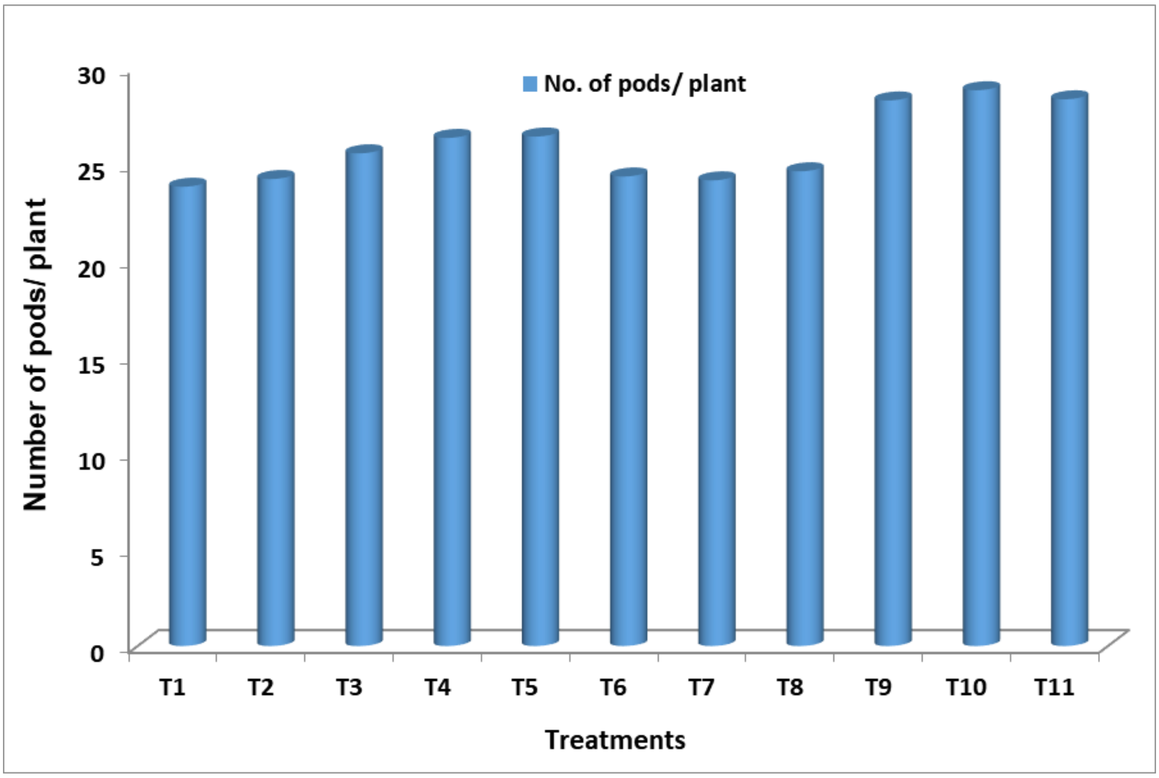

Fig 2: Effect of different treatments on number of pods / plant of blackgram

Grain and straw yield

Application of GA_3 significantly influenced the blackgram crop grain yield (Table 5) and (Fig.3). Two applications of 30 ppm GA_3 at flower initiation and at pod initiation stages (T10) recorded significantly higher grain yield (2266 kg/ ha) and it was higher by 14% than control treatment (1944 kg/ ha). The effect of foliar application of GA_3 on straw yield and biological yield of the blackgram crop was found non-significant (Table 5). However, single application of 45 ppm GA_3 at flower initiation stage recorded the highest straw yield and biological yield (4405 and 6655 kg/ ha), whereas single application of GA_3 flower initiation stage recorded the lowest straw yield and biological yield (3889 and 5940 kg/ ha).

Table 5: Effect of different treatments on grain yield, straw yield, biological yield (kg/ ha), harvest index and rainfall use efficiency (kg/ ha/mm) of blackgram

Treatments	Grain yield (kg/ ha)	Straw yield (kg/ ha)	Biological yield (kg/ ha)	Harvest index (%)	Rainfall use efficiency (kg/ha/mm)
T_1: Control (No spray)	1944	4048	5992	32.75	2.84
T_2: Water Spray at flower + pod initiation	1960	4127	6087	32.35	2.86
T_3: 15 ppm GA_3 at flower initiation	2163	4206	6369	33.97	3.16
T_4: 30 ppm GA_3 at flower initiation	2262	4246	6508	34.79	3.30
T_5: 45 ppm GA_3 at flower initiation	2250	4405	6655	33.80	3.28
T_6: 15 ppm GA_3 at pod initiation	1992	4008	6000	33.21	2.91
T_7: 30 ppm GA_3 at pod initiation	2063	4127	6190	33.33	3.01
T_8: 45 ppm GA_3 at pod initiation	2052	3889	5940	34.53	3.00
T_9: 15 ppm GA_3 at flower + pod initiation	2246	4286	6532	34.38	3.28
T_{10}: 30 ppm GA_3 at flower + pod initiation	2266	4206	6472	35.01	3.31
T_{11}: 45 ppm GA_3 at flower + pod initiation	2262	4365	6627	34.13	3.30
S.E. (m) $\pm$	83	216	287	0.72	0.12
CD (P=0.05)	242	NS	NS	NS	0.35
GM	2133	4174	6307	33.84	3.11

Assimilate translocation to reproductive sinks is vital for seed development. Seed set and filling cab be limited by availability and utilization assimilates (Asch *et al*., 2005) [5]. The grain yield of blackgram crop was increased due to cumulative effect of yield attributing characters, enhanced photosynthetic efficiency and improvement in the capacity of the reproductive sinks to utilize the incoming assimilates due to the foliar application of GA_3. Similar results were observed by Upadhyay and Ranjan (2015) [15] in soybean crop and Tiwari *et al.* (2018) [13] in mungbean crop.

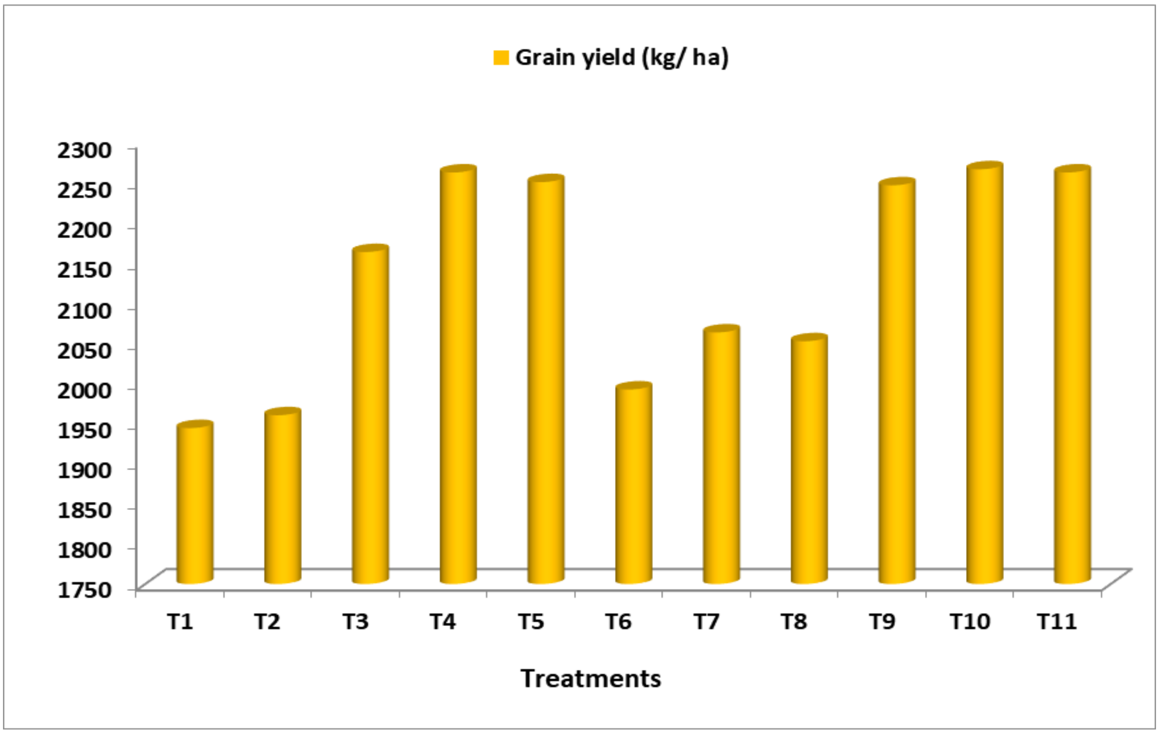

Fig 3: Effect of different treatments on grain yield (kg/ ha) of blackgram.

Harvest index

The effect of foliar application of GA_3 on harvest index of the blackgram crop was found non- significant (Table 5). However, two applications of 30ppm GA_3 at flower and pod initiation stages recorded the highest harvest index (35.01%), whereas two applications of water spray at flower and pod initiation stages (T2) recorded the lowest harvest index (32.35%). The higher harvest index indicated that, GA_3 application accelerated assimilate supply to sink and better utilization of the incoming assimilates by the reproductive sinks. Similar results were observed by Akter *et al.* (2007) [2] in mustard crop and Akbari *et al.* (2008) [1] in mung bean crop.

Rain water use efficiency (RUE)

Rain water use efficiency (kg/ mm/ ha) was significantly influenced by the application of GA_3 (Table 5) and (Fig.4). Two applications of 30ppm GA_3 at flower and at pod initiation stages (T10) recorded higher rain water use efficiency (3.31 kg/ mm/ ha). The lowest rain water use efficiency was observed with no application of GA_3 (2.84 kg/ mm/ ha). The best treatment recorded 14% more rain water use efficiency than that of the control treatment. Our results clearly indicate that application of GA_3 resulted in enhancing the effective use of rainfall by the blachgram crop. Similar results were observed by Giri *et al.* (2018) [9] in pigeonpea crop.

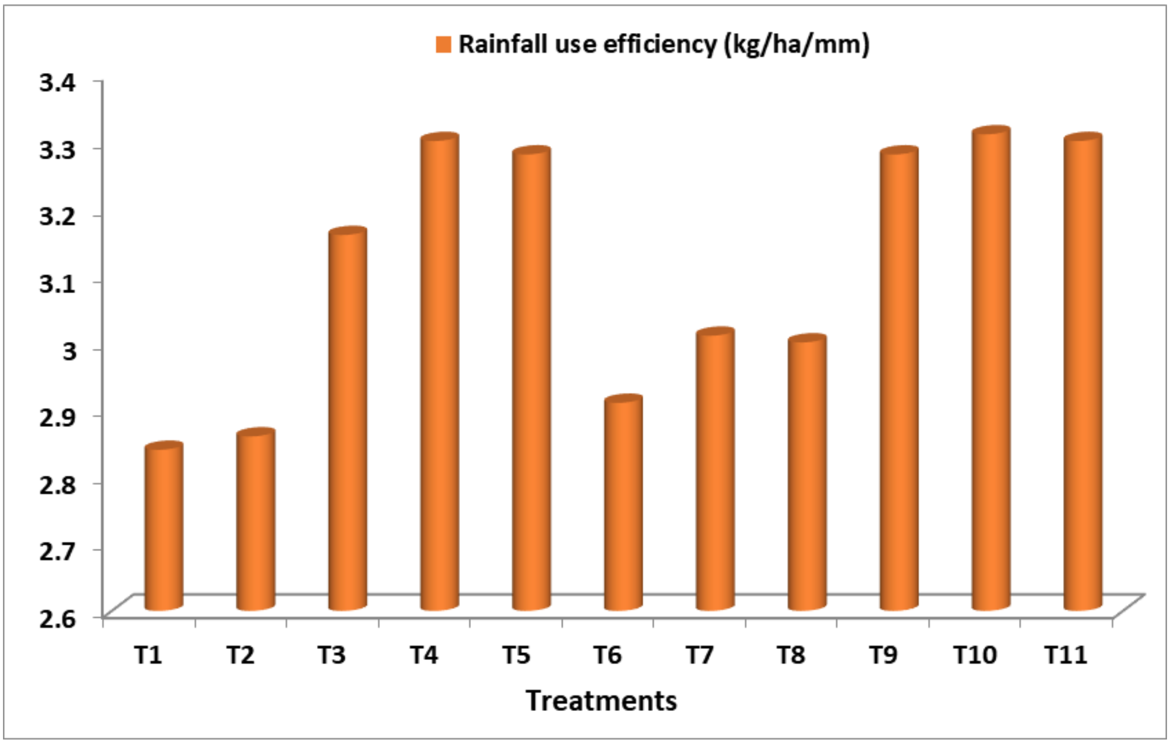

Fig 4: Effect of different treatments on rainfall use efficiency (kg/ ha/mm) of blackgram

Economics

Economics of blackgram production was significantly influenced by the GA_3 application (Table 6) and (Fig.5). Two applications of 30 ppm GA_3 at flower and pod initiation stages (T10) recorded significantly higher gross returns (Rs. 126889/-), which was higher by Rs. 18000/- than that of no application of the GA_3 (Rs. 108889/-). The effect of application of GA_3 on net monetary returns of the blackgram crop was found non- significant. The benefit: cost ratio was higher with the single application of 30ppm GA_3 at flower initiation stage (5.42). Increased grain yield owing to application of GA_3 significantly increased the gross and net monetary returns. Similar results were observed by Aziz *et al.* (2012) [6] in soybean crop.

Table 6: Effect of different treatments on economics of blackgram

Treatments	Economics			
	Cost of cultivation (Rs./ ha)	**Gross monetary returns (Rs./ ha)**	**Net monetary returns (Rs./ ha)**	**B:C Ratio**
T_1: Control (No spray)	21989	108889	86900	4.95
T_2: Water Spray at flower + pod initiation	22037	109778	87741	4.98
T_3: 15 ppm GA_3 at flower initiation	22801	121111	98310	5.31
T_4: 30 ppm GA_3 at flower initiation	23374	126667	103293	5.42
T_5: 45 ppm GA_3 at flower initiation	23725	126000	102275	5.31
T_6: 15 ppm GA_3 at pod initiation	22459	111556	89097	4.96
T_7: 30 ppm GA_3 at pod initiation	22977	115556	92578	5.03
T_8: 45 ppm GA_3 at pod initiation	23328	114889	91561	4.92
T_9: 15 ppm GA_3 at flower + pod initiation	23342	125778	102436	5.39
T_{10}: 30 ppm GA_3 at flower + pod initiation	24132	126889	102757	5.26
T_{11}: 45 ppm GA_3 at f flower + pod initiation	24874	126667	101793	5.09
S.E. (m) $\pm$	21989	4628	4502	4.95
CD (P=0.05)	22037	13538	NS	NS
GM	23374	119434	96249	5.42
Gross returns were calculated on the basis of MSP of blackgram @ Rs. 5600/q for the year 2018-19				

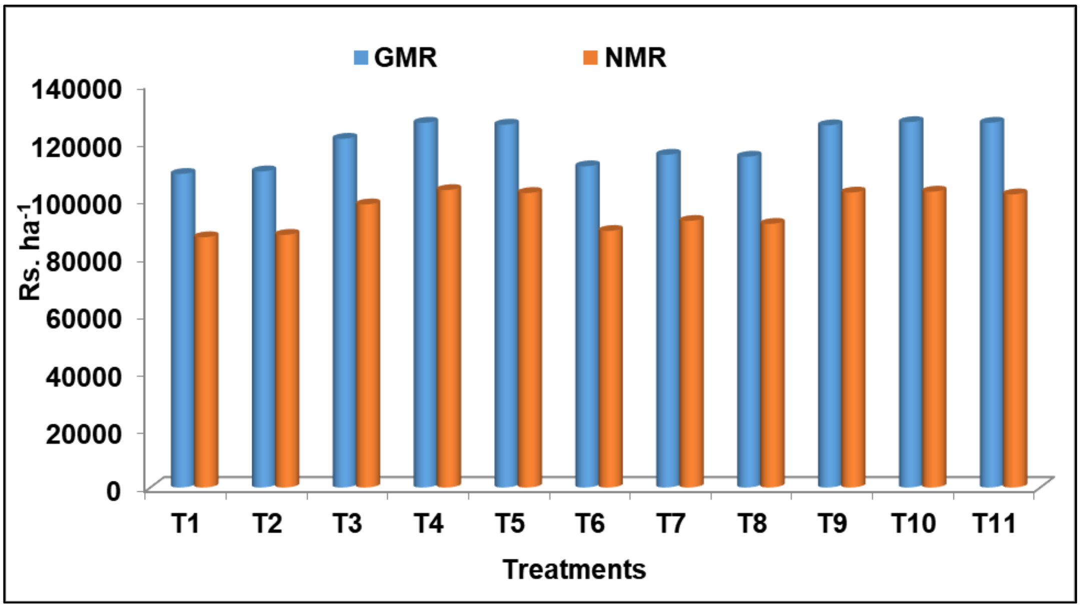

Fig 5: Effect of different treatments on economics of blackgram

Conclusions

Two applications of 30ppm GA_3 at flower and pod initiation stages recorded significantly highest number of pods $cluster^{-1}$, length of pod, number of grains pod^{-1} number of pods $plant^{-1}$, grain yield $plant^{-1}$, grain yield (kg ha^{-1}) and recorded significantly higher rainfall use efficiency. Two applications of 30ppm GA_3 at flower and pod initiation stages recorded significantly higher gross monetary returns. However the B: C ratio was higher with the single application of 30ppm GA_3 at flower initiation stage.

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