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Influence of Integrated Nutrient Management on Growth and Yield of Bt Cotton (*Gossypium hirsutum* L.) Hnder Dry Farming Condition

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ABSTRACT: The field experiment was conducted during *kharif* seasons of 2008-2013 on medium black soil at Dry Farming Research Station, Junagadh Agricultural University; Targhadia to study the effect of integrated nutrient management (INM) techniques on seed cotton yield, economics and soil physico-chemical properties under dry farming condition. The experiment was laid out in randomized block design with ten different treatment combinations comprising of organic and inorganic fertilizers (NPK), gypsum, castor cake, compost and vermi-compost replicated in a thrice. The experimental result showed that the significantly higher seed cotton yield (2298 kg/ha) and highest net return (₹ 98289/ha) were recorded under treatment T_9 (80 kg/ha + 10 tones compost/ha + 500 kg castor cake/ha + bio-fertilizer-*Azotobacter* + PSM). The highest number of branches/plant, numbers of balls/plant and plant height (cm) were also recorded under treatment T_9.

Key words: Seed **c**otton, integrated nutrient management, sustainable yield index

Introduction

Cotton 'the king of apparel fibers' is an important cash crop and it supplies a major share of raw material for the textile industry and playing a key role in the economic and social affairs of the world (Hosamani *et al*., 2013). It is grown chiefly for its fiber, which is used in the manufacture of cloths, making of threads and extraction of oil from cotton seed (Deshmukh *et al.,* 2013). The Cotton (*Gossypium hirsutum* L.), an important fiber crop, is grown throughout India under both rainfed and irrigated conditions on an area of 9.5 M ha (Mayee *et al.,* 2008; Yang *et al.,* 2014). India ranks first in area and production, but productivity levels of cotton in India (544 kg/ha) are far below the world average (704 kg/ha).

The cultivation of cotton is increasing day by day in North Saurashtra Agro-climatic Zone due to change in rainfall pattern, sustained price at a higher level, demand for export and introduction of pest resistant variety. Nitrogen, phosphorus and potassium are primary element which helps in increasing of agricultural crop production. Among these, nitrogen is one of the decisive as well as expensive inputs, which has quickest and most pronounced effect on plant growth. As a constituent of protoplasm, it is intimately involved in the process of photosynthesis and ultimately, in the dry matter production. Potassium plays an important role in fibre development, enzyme activation, pH balance in cell, translocation of carbohydrates and plant health and disease suppression. The organic manures play an important role in crop production (Usman *et al.,* 2013). It acts favorably on the soil physical properties and promotes formation of soil crumbs, thus makes the soil friable and the thereby facilitates the proper movement of air and water as well as infiltration of rainwater. It also adds plant nutrients to the soil during its decomposition. Beside this, it also acts on the insoluble nutrient reserve in the soil and make them available biologically as it provides food for the beneficial soil microorganisms.

Proper management of organic and inorganic fertilizers are useful for higher dry matter accumulation, increase the number of bolls/plant and increase in seed cotton yield of Bt cotton (Narayan *et al.*, 2011). For getting maximum production, farmers are in the practice of using more and more chemical fertilizers. Under such a situation, it is essential to evolve and adopt a strategy of integrated nutrient management by using a judicious combination of chemical fertilizers and organic manures which may not only increase production but also improve soil health for sustaining the productivity. Keeping in view, this experiment was planned to study the effect of integrated nutrient management in Bt cotton for sustaining yield and soil fertility under dry farming conditions.

Materials and Methods

The field experiment was carried out on dry farming Bt. Cotton during *kharif* seasons of 2008-2013 at Dry Farming Research Station, Junagadh Agricultural University, Targhadia (Dist: Rajkot, Gujarat, India). The soil of the experimental site was clayey in texture with moderately alkaline in reaction (pH 8.01) and non saline (EC 0.19 dS/m). The initial status of soil was low in organic carbon (4.93 g/kg soil), medium in available P (20.3 kg P_2O_5/ha) and high in available K (346 kg K_2O/ha). The experiment was laid out with ten different treatment combinations replicated in thrice. The experiment was comprised of 10 treatments combinations T_1 : control, T_2 :10 t compost/ha, T_3 : 80 kg N/ha, T_4 : T_3 + 40 kg P_2O_5 /ha, T_5 : T_3+ 40 kg K_2O/ha, T_6 : T_3 + 40 kg P_2O_5/ha + 40 kg K_2O/ha, T_7 : T_3 + 40 kg P_2O_5 /ha +250 kg gypsum/ha, T_8 : T_3+ 500 kg castor cake/ha, T_9 : T_3 +10 t compost/ha + 500 kg castor cake/ha + bio-fertilizer (*Azotobacter* + PSM) each one kg/ha and T_{10} :10 t compost/ha + 1 t vermi compost/ha + 500 kg castor cake/ha + bio-fertilizer, each replicates thrice in random block design with the plot size of (a) Gross: 5.4 m x 4.5 m (b) Net: 3.6 m

x 2.7 m. The spacing and seed rate were 90 cm x 30 cm and 1.250 kg/ha, respectively. The fertilizers were applied as per treatment combinations. The 80 kg N/ha was applied in three splits as 20 kg N/ha as basal, 40 kg N/ha as top dressing at 35-40 days and 20 kg N/ha as top dressing at 60-65 days after sowing. The crop was sown at onset of monsoon in June-July. In all the years same plots were maintained as fixed without disturbance. The cultural operations were carried out as and when required as per practices. Observations on growth and yield attributes, seed cotton yield were recorded and analyzed statistically.

The sustainable yield index was computed on the basis of the yield obtained from 2008-2013 and annual rainfall as described by Vittal *et al.* (2002). The regression of mean yield with annual rainfall was derived, then the estimate of error (σ) was computed. Based on the following equation SYI was calculated

$$SYI = \frac{Y - \sigma}{Ymax} X\ \mathbf{100}$$

where, Y is the estimated average yield of a practice across the years. σ is its estimated standard error based on average rainfall of five years, and Ymax is the observed maximum yield in the experiment during the years of cultivation.

The Rain Water Use Efficiency (RWUE) was calculated by dividing the seed cotton yield (kg/ha) to cumulative rainfall (mm) from sowing to harvest. RWUE (kg/ha/mm) indicates yield attained by treatment per millimeter of rain water received during the cropping period. Since there is no irrigation to the crop other than rain water, RWUE would indicate the water productivity or water use efficiency of a treatment under dry land condition.

Results and Discussion

Rainfall feature

There was wide variation in yearly and monthly rainfall amount (Table 1 and Figure 1). Rainfall varied from 404.5 to 1144.5 mm in rainy days from 17 to 38 with a standard deviation of -36.6 to + 91.3 %. The distribution of rainfall was uneven during the year 2009, 2012 and 2013 and that of equal in years 2010 and 2011. Onset of monsoon was varied from 22nd to 27th std. week, while, withdrawal of monsoon was recorded from 35th to 41st Std. week. Long dry spells was recorded during the years 2009 and 2012. Heavy rain storms of 112, 200 and 300 mm were recorded during the year 2009, 2011 and 2013, respectively.

Growth parameters/yield attributes

The plant height was significantly influenced by treatments. The treatment T_7 was found superior to other treatments, i.e. T_1: control, T_2: 10 t compost/ha, T_3: 80 kg N/ha and T_{10}: 10 t compost/ha + 1 t vermi compost/ha + 500 kg castor cake/ha + bio-fertilizer (Table 2). Similarly, the number of branches/ plant and numbers of balls/plant, plant height (cm) were also significantly influenced by treatments and maximum values were recorded under treatment T_9 which were statistically at par with treatments T_4 to T_8 and T_{10}. These happen because crop got nutrients and moisture for a longer time due to application of nutrients through organic and inorganic sources. Sridevi and Ramakrishan (2010) also found similar results in a combination of NPK fertilizer and fungi.

Table 1 : Rainfall feature during experimentation period

Year	Seasonal rainfall (mm)	Rainy days	% Deviation to normal	On set of monsoon	Rainfall distribution	Dry spell	Withdrawn of monsoon	Event
2009	458.2 (-)*	17	-26.1	25th Std. week	Uneven	27th July to 29th August)	35th Std. week	Heavy rainfall on 18th July 112.0 mm
2010	1144.5 (60)	46	+91.3	22nd Std. week	Even	-	37th Std. week	-
2011	1044.3 (18.0)	33	+79.7	27th std. week	Even	-	39th std. week	Heavy rainfall on 9th 145 mm & 18th July 200 mm
2012	404.5 (-)	21	-36.6	24th Std. week	Uneven	18th June to 2nd July and 14th July to 24th August	38th Std. week	-
2013	1101.4 (26.2)	38	+76.2 %	24th std. week	Uneven		41st Std. week	Heavy rainfall on 26th September 300 mm

*Figure in parenthesis indicated pre or post seasonal rainfall

Seed cotton yield

There was wide variation in seed cotton yield between year to year might be due to variation in rainfall features during the experimental periods (Table 1). The result revealed that seed cotton yield was significantly affected due to different treatments during all the years (Table 2). Treatment T_9 was found superior to other treatments in comparison to T_1 (control) except seed cotton yield during 2010-11.

In pooled results, seed cotton yield was significantly influenced by treatments. Seed cotton yield varied from 1138 to 2302 kg/ha and the treatment T_9 was found superior to other treatments, i.e. T_1, T_2 and T_{10} (Table 2). The seed cotton yield increased to the tune of 19.7% under T_9 in comparison to T_2 (80 kg N/ha – recommended dose of fertilizer) on account of balance supply of nutrients through organic and inorganic sources which improved physical and chemical properties of soil. Hence, integrated use of organics with inorganic fertilizers has considerable importance as to take remedial measures in fertility management and boosting the production. Similar results were found by various researchers, which demonstrated the positive outcomes of integrated nutrient management in many areas (Kumari *et. al.,* 2010, Laekemariam and Gidago, 2012; Islam *et al.,* 2014). The data further indicated that seed cotton yield under treatments T_2 and T_{10} was lower in comparison to seed cotton yield under treatments T_3 to T_8 might be due to the reason that organic sources only could not fulfil the major nutrient requirement for high yielding long duration crop like Bt cotton.

The Rain Water Use Efficiency (RWUE) varied from 1.6 to 3.23 kg/ha/mm under different treatments (Table 2). Minimum and maximum values of RWUE were recorded with treatments T_1 and T_9, respectively. The data further indicated that RWUE was comparatively higher with treatments having nutrients supplied either through inorganic fertilizers or their integration with organic sources.

Economics

The economic response of cotton to nutrient management was worked out on the basis of pooled result and presented in Table 3. The data indicated that application of 80 kg N/ha + 40 kg P_2O_5/ha + 250 kg gypsum/ha T_7) gave the highest net return (₹ 90125/ha) followed by T_9 (80kg N/ha + 10 t compost/ha + 500 kg castor cake/ha + bio-fertilizer. However, higher values of benefit: cost ratio (3.98 to 4.72) was recorded with treatments receiving nutrients through inorganic fertilizers only in comparison to nutrients supplied either through organic sources or their integration with inorganic sources (2.18 to 2.88).

Sustainability

The sustainable yield index values, which are the measure of sustainability of the treatments were high in T_9 :80kg N/ha + 10t compost/ha + 500kg castor cake/ha + bio-fertilizer (46.4 %) irrespective of variation in weather conditions in five years (Table 4). This was followed by treatment T_7: 80 kg N/ha + 40 kg P_2O_5/ha + 250 kg gypsum/ha (44.6). Gabhane *et al.* (2014) reported that the numerically higher sustainable yield index (SYI) was recorded with application of 50% RDF + FYM @ 15 t/ha. Thus, comparatively lower values of SYI among the treatments having only chemical fertilizers than the integrated use of FYM and fertilizers suggest that the combined use of both inorganic and organic sources brings more sustainability of yield on long-term basis. Similar finding were also reported by Bhagwan Sonune *et al.* (2013).

Table 2 : Effect of integrated nutrient management on yield attributes of cotton

Treatment	Plant height (cm)/ plant	No. of branches/ plant	No. of balls/ plant
T_1: Absolute control	85	9.37	10.47
T_2: 10 t compost/ha	92	10.95	12.00
T_3: 80 kg N/ha (RDF)	96	10.71	13.17
T_4: T_3 + 40 kg P_2O_5/ha	100	11.40	14.57
T_5: T_3 + 40 kg K_2O/ha	101	11.33	14.65
T_6: T_3 + 40 kg P_2O_5/ha + 40 kg K_2O/ha	102	11.67	15.08
T_7: T_3 + 40 kg P_2O_5/ha + 250 kg Gypsum/ha	104	11.95	15.31
T_8: T_3 + 500 kg castor cake /ha	101	11.72	14.75
T_9: T_3 +10 t compost/ha + 500 kg castor cake/ha + bio-fertilizer (Azotobacter + PSM)	108	12.23	17.35
T_{10}: 10 t compost/ha + 1 t vermi compost/ha + 500 kg castor cake /ha+ bio-fertilizer (Azotobacter + PSM)	95	11.11	13.17
C.D. (P=0.05)	7.77	1.09	3.01

Table 3 : Effect of integrated nutrient management on seed cotton yield (kg/ha) and RWUE

Treatment	2009-10	2010-11	2011-12	2012-13	2013-14	Pooled	RWUE kg/ha/mm
T_1: Absolute control	723	1007	945	1210	1804	1138	1.60
T_2: 10 t compost/ha	1010	1193	1140	2241	2605	1638	2.45
T_3: 80 kg N/ha (RDF)	990	1700	1893	2122	2904	1922	2.67
T_4: T_3 + 40 kg P_2O_5/ha	1011	2097	2003	2134	3090	2067	2.81
T_5: T_3 + 40 kg K_2O/ha	1147	1987	2044	2200	3253	2126	2.92
T_6: T_3 + 40 kg P_2O_5/ha + 40 kg K_2O/ha	1131	2115	1919	2166	3214	2109	2.89
T_7: T_3 + 40 kg P_2O_5/ha + 250 kg Gypsum/ha	1269	2233	1872	2360	3287	2204	3.07
T_8: T_3 + 500 kg castor cake /ha	1134	2045	1821	2155	3060	2043	2.82
T_9: T_3 +10 t compost/ha + 500 kg castor cake/ha + bio-fertilizer (Azotobacter + PSM)	1344	2034	2238	2527	3368	2302	3.23
T_{10}: 10 t compost/ha + 1 t vermi compost/ ha + 500 kg castor cake /ha+ bio-fertilizer (Azotobacter + PSM)	1012	1255	1328	2296	2669	1712	2.54
C.D. (P=0.05)	259	375	259	581	1023	396	-

Table 4 : Effect of integrated nutrient management on economics

Treatment	Cotton seed yield kg/ha	Gross income ₹/ha	Cost of cultivation (₹/ha)	Net return (₹/ha)	B:C ratio	Sustainable yield index (SYI) %
T1	1138	56900	16150	40750	2.52	40.3
T2	1638	81880	22400	59480	2.66	34.8
T3	1922	96091	17411	78680	4.52	42.3
T4	2067	103350	19977	83373	4.17	43.0
T5	2126	106310	18592	87718	4.72	42.2
T6	2109	105450	21158	84292	3.98	42.5
T7	2204	110200	20075	90125	4.49	44.6
T8	2043	102150	20911	81239	3.88	44.1
T9	2302	115100	27011	88089	3.26	46.4
T10	1712	85600	26950	58650	2.18	37.0

Conclusion

The results indicate that in the medium black soils of North Saurashtra Agro climatic zone under dry farming condition Bt. Cotton gave higher net returns with 80 kg N + 40 kg P_2O_5 + 250 kg gypsum per hectare. This was followed by integration of inorganic + organic, i.e. 80kg N/ha + 10t compost/ha + 500 kg castor cake/ha + bio-fertilizer. These two treatments maintained higher sustainability under dry farming condition.

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