INFLUENCE OF EYE NUMBER ON A SEED AND POTASSIUM ON GROWTH AND YIELD OF TURMERIC

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*This is to certify that the thesis entitled "**Influence of Eye Number on a Seed and Potassium on Growth and Yield of Turmeric**" submitted to the Department of Horticulture and Postharvest Technology, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE in HORTICULTURE**, embodies the result of a piece of bona fide research work carried out by Gazi Nazmul Hasan, Registration No. 07-02634 under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

I further certify that any help or source of information, received during the course of this investigation has been duly acknowledged.

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DEDICATED
TO
MY BELOVED PARENTS
AND
DEPARTED
BROTHER-IN-LAW

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ABSTRACT

The study was conducted at the Horticultural Farm of Sher-e-Bangla Agricultural University, Dhaka during the period from April 2008 to April 2009. The experiment consisted of two factors. Factor A: Three levels of number of eye in each rhizome, E_1 : 1 eye, E_2 : 2 eyes and E_3 : 3 eyes and Factor B: Four levels of potassium, K_0 : 0 kg, K_1 : 90 kg, K_2 : 110 kg and K_3 : 130 kg K_2O/ha respectively. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. In case of number of eyes, the highest yield (24.58 t/ha) was recorded from E_2 and the lowest (22.31 t/ha) was from E_1. In case of potassium, the highest yield (26.81 t/ha) was observed from K_3 and the lowest (15.14 t/ha) was found from K_0. For combined effect E_2K_3 produced the highest yield (28.82 t/ha) and lowest (14.89 t/ha) from E_1K_0. The highest benefit cost ratio (2.50) was noted from E_2K_3 and the lowest (1.38) from E_1K_0. So, two eyed rhizome with 130 kg K_2O/ha was found suitable for growth and yield of turmeric.

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LIST OF ABBREVIATED TERMS

ABBREVIATION	FULL NAME
AEZ	Agro-Ecological Zone
ANOVA	Analysis of Variance
BBS	Bangladesh Bureau of Statistics
cm	Centimeter
°C	Degree Celsius
DAP	Days After Planting
DMRT	Duncan's Multiple Range Test
et al.	and others
etc	Et cetera
FAO	Food and Agriculture Organization
ha	Hectare
hr	Hour
kg	Kilogram
m	Meter
mm	Millimeter
m^2	Square meter
MOP	Muriate of Potash
no.	Number
PT	Postharvest Technology
RCBD	Randomized Complete Block Design
SAU	Sher-e-Bangla Agricultural University
TSP	Triple superphosphate
UNDP	United Nations Development Program
%	Per cent

CHAPTER I
INTRODUCTION

CHAPTER I

INTRODUCTION

Turmeric (*Curcuma Longa L.)* is an important spice among the rice consumers in India, South East Asia and Indonesia, and is indispensable in the preparation of curry powder. It is a native of India or China is now a commercial crop of the tropics and sub-tropics. It is one of the earliest oriental spices known to Western World and still in large demand (Purseglove *et al.*, 1981).Turmeric is a unique, colourful and versatile natural plant product combining the properties of flavourant and colourant (Shankaracharya and Natarajan, 1971).

The major use of turmeric on a world-wide basis is for domestic culinary purposes. In the estern industrialized countries, ground turmeric is employed extensively in a wide range of processed foods and sauces. It is also used as dye stuff in certain cotton textiles and in cosmetics. The oleoresin finds similar applications to the ground spice in the colouring of processed foods and it is also used by the pharmaceutical industry. In addition to its use as a spice, it has other uses that are prominent in the life of the people of southern Asia, and has acquired magical properties in connection with birth, marriage, death and in agriculture. It serves as a multipurpose herbal remedy for practitioners of Ayurveda, Siddha, Unani and practitioners of traditional Chinese medicine. Turmeric is also used to treat asthma, dysmenorrhoea, psoriasis, eczema, arthritis, and hepatic and digestive disorders and to prevent and treat cardiovascular diseases. In Unani medicine system, turmeric is used to treat liver obstruction, dropsy, jaundice, ulcers and inflammation (Sakarkar *et al.*, 2006).

In Bangladesh, total production of turmeric is about 1.3 lakh metric ton in an area of 22.91 thousand hectare (BBS, 2008). Turmeric grows well in Nilphamari, Dinajpur, Rangpur, Khulna, Tangail, Mymensingh, Rangamati, Bandarban and Khagrachari districts of Bangladesh. In fact, India still enjoys the unique position of being the largest producer and exporter of turmeric in the world. Other known producers include Jamaica, Srilanka, Taiwan, the People's Republic of China, Burma, Thailand, Indonesia, Peru and Haiti, although it is certain that the spice is grown in many other countries in southern and East Asia. The spice turmeric or haldi consists of the dried, boiled, cleaned, and polished rhizomes (the underground swollen stem of the plant) of *Curcuma longa*. (Pruthi. J.S.1976). It requires a hot and humid climate. It can be cultivated in most areas of the tropics and subtropics provided that rainfall is adequate or facilities for irrigation are available. It is usually grown in regions with an annual rainfall of 1000-2000 mm. Cultivation has been extended into moist areas with rain above 2000 mm per annum. It can be grown up to an altitude of 1220 m in the Himalayan foothills (Purseglove *et al.*, 1981).

Farmers use their own management practices to grow turmeric which results in uneconomic return. Ignorance of suitable planting material and the negligence about the use of balance fertilizer are to the salient features of such practices. Plant morphology and growth habit of a crop mostly depends on the planting material (Onwueme, 1978). Turmeric responds greatly to major essential elements like N, P and K for its growth and yield (Mital *et al.*, 1975; Singh *et al.*, 1976; Thompson and Kelly, 1988). Potassium plays a vital role for proper growth and development of plants. Application of potassium in appropriate time and dose is prerequisite for any crop cultivation .Generally, a large amount of potassium is required for the cultivation of turmeric (Opena *et al.*, 1988).

Potassium is also one of the important essential macro elements for growth and development of plant. The potassium requirements vary depending upon the nutrient content of the soil (Bose and Som, 1986). It is also essential for cell organization, hydration and cell permeability. It is an essential element of chloroplast too. It helps photosynthesis by maintaining iron supply and increases the body substrates. Potassium improves root system of turmeric, so that the roots can absorb the minerals and irons from soil solution efficiently, resulting with higher yield. Potassium progressively increases the yield (Obreza and Vavrina, 1993) but an adequate supply is essential for vegetative growth, and desirable yield (Yoshizawa and Roan, 1981). Excessive application is not only uneconomical but also induces physiological disorder.

In spite of its immense importance very little information is available on the sustainable production technology of the crop in Bangladesh. Considering the above facts, the present study was undertaken with the following objectives-

- to find out the suitable number of eyes on a seed which impact the best yield of turmeric
- to determine the optimum doses of potassium in order to get the maximum yield
- to find out the suitable combination between eyes on a seed and potassium to ensure the higher yield of turmeric

CHAPTER II

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

Turmeric is an important spices crop in Bangladesh and in many countries of the world. The crop has conventional less concentration by the researchers on various aspects because normally it grows without care or management practices in fallow land. For that a very few studies related to growth, yield and development of turmeric have been carried out in our country. So the research work so far done in Bangladesh is not adequate and conclusive. Nevertheless, some of the important and informative works and research findings related to the eye number on a seed and potassium so far been done at home and abroad on this crop and other crop have been reviewed in this chapter.

2.1 Influence of eye number

Pirjade *at al.* (2007) conducted an experiment at the University Department of Horticulture, Dr. PDKV, Akola, Maharashtra, India, during 2003-04 to study the performance of six turmeric cultivars, viz. Brahmani, Krishna, Salem, Suverna, Tekurpeta and Waigaon with different number of eyes in rhizome (2, 3 and 4). The results indicated that, growth in terms of plant height and pseudostem girth were found maximum in Waigaon whereas, leaves per plant, tillers per plant were found maximum in Krishna for increasing number of eyes . In respect of yield and contributing characters, i.e. weight of mother rhizomes per plant, per plot and per hectare, weight of fresh fingers per plant, per plot and per hectare were found maximum in Krishna for 2 number of eyes.

Singh and Prasad (2006) carried out an experiment with sixteen *C. longa* (turmeric) cultivars with 2 and 3 eyes per rhizome were evaluated for yield and yield components in Muzaffarpur, Bihar, India,. Significant differences were observed among the cultivars with respect to plant height. Plant height was greatest in ACC-657 (119.67 cm), followed by ACC-585 (198.98 cm). However, the cultivars did not significantly vary for number of branches per plant. ACC-657 and ACC-585 required a longer period to maturity (262 and 238 days, respectively). RH-5 recorded the highest yield (49.76 t/ha) and a fresh rhizome yield of 5.69 t/ha, which 12.91% higher than the yield of Rajendra Sonia (control) for number of 2 eyes. The cost : benefit ratio was highest for RH-5 (1:2.50) for 2 number of eyes.

Hanamashetti *et al.* (2002) studies on the comparative performance of promising cultivars of turmeric (*Curcuma longa* L.) when finger and mother rhizomes were used as planting material with 1, 2 and 3 eyes revealed variation in growth and yield in different cultivars. Krishna gave maximum cured yield per hectare in both finger and mother rhizomes as planting material with 2 eyes. Cultivars Amalapuram (8.96 t/ha) and Salem (8.03 t/ha) which gave high yield in case of mother rhizomes as planting material gave less yield in case of finger rhizomes as planting material indicating their suitability of mother rhizomes as planting material for high yield for 3 eyes.

Yoyhasiri *et al.* (1997) studied the effect of type and size of seed rhizome on the growth and yield of *Curcuma longa* at Kaohinson Research Stastion, Panomsarakam district, Thiland. Seed rhizome giving the highest yield per unit area were the half cult mother rhizomes with two eyes (22.13 t/ha) followed by the whole mother rhizomes with double number of eyes (20.75 t/ha) and the primary rhizomes with 5-6 internodes (17.76 t/ha). Half cut mother rhizomes produced the most rapid growth and development of plants. The primary, secondary and tertiary rhizomes with 3-4 internodes did not differ from one another in terms of growth and yield.

Maia *et al.* (1995) reported that in greenhouse trials in Campinas, Sao Paulo Brazil, turmeric plants originating from primary rhizomes with 2-3 number of eyes had a greater leaf area and total dry weight, and a highest yield of new rhizomes (up to 50% more), than plants produced from secondary rhizomes with 2-3 eyes.

Govinden and Cheong (1995) carried out a trial with turmeric at the Constance Sugar Estate in the east of Mauritius to compare the merits of mother tubers and rhizomes with different number of eyes as planting materials. Sprouting and emergence were increased when mother tubers were cut into two. The number of aerial stems that emerged from each seed piece was increased slightly, but not proportionally, with seed piece size. This was significantly, but not proportionally, with seed piece size. This was significant because a linear relationship was found between yield and number of stems. Rhizomes are easier to clean than tubers and plant grown from rhizomes yielded a higher proportion of rhizomes than plants grown from tubers with minimum eyes.

2.2 Influence of potassium fertilizers

Akamine *et al.* (2007) conducted a glasshouse experiment was to evaluate the effects of N, P and K, alone or in combination, on the growth, yield and curcumin content of turmeric on dark red soil. Results indicated that separate application of P and K could not increase the growth and yield of turmeric, whereas N alone increased both growth and yield. The combined application of N and K (NK) or N, P and K (NPK) provided 4 to 6 times greater shoot biomass and 8 to 9 times higher yield. K alone provided the highest curcumin content in rhizome, but did not increase turmeric yield. On the other hand, NPK provided the highest yield but did not increase curcumin content. NK provided the second highest yield with the second highest curcumin content, indicating that this is the best combination for promoting yield and curcumin content.

Swain *et al.* (2006) find out the effects of N, P and K fertilizer rates (0:0:0, 60:30:90, 80:40:100, 100:50:110 and 120:60:120 kg/ha) and mulching on the growth, yield and economics of turmeric (cv. Surama) production. The growth parameters, yield attributes (plant height, number of leaves per plant, rhizome weight, and number or primary and secondary fingers per plant), and fresh rhizome yield were significantly increased by increasing the N:P:K levels from 0:0:0 to 120:60:120 kg/ha, and by mulching. The highest yield of green rhizomes

(19.1 t/ha) was obtained with 120:60:120 kg N:P:K/ha, but the highest benefit cost ratio (2.75) was obtained with 100:50:110 kg N:P:K /ha.

Majumdar, *et al.* (2005) conducted an experiment on the response of ginger cv. Nadia to five levels of K (0, 50, 100, 150 and 200 kg/ha) and 2 levels of farmyard manure (0 and 5 tonnes/ha) and consequent changes in form of K in soil. They reported that rhizome and straw yield of ginger; N and P uptake increased significantly up to 100 kg K/ha while oleoresin content increased significantly with increasing K levels. The crop showed high consumption of K beyond 100 kg K/ha. All forms of soil K increased significantly up to 200 kg/ha. Application of farmyard manure had positive and significant effect on yield, nutrient uptake and K build up in soil. A combined dose of 100 kg K and 5 tonnes farmyard manure/ha was optimum for higher productivity and quality of ginger, maximum K use efficiency (30.9%) with adequate K build up in a Typic Hapludalf.

May *et al.* (2005) conducted an experiment to determine the effects of N (0, 68, 136, 170 and 204 kg/ha) and K (0, 93, 184, 230 and 276 kg/ha) on the development and production of turmeric in Sao Paulo, Brazil during 1999-2000 by. Plant height increased with increasing K rates. Application of 0 or 92 kg /ha in combination with increasing rates of N resulted in increasing number of leaves of the progeny plants. The number of progeny plants increased with increasing K rates. Rhizome production was not affected by the treatments.

Silva *et al.* (2004) were evaluated in Goias, Goiana, Brazil with turmeric growth and production, as a result of mineral fertilizer and planting density. The first experiment was conducted during January-August 1998. The treatments consisted of different rates of urea, triple superphosphate, and potassium chloride (0, 40, 80, 120, 160, and 200 kg/ha of N; 0, 50, 100, 150, 250, and 400 kg/ha of P and 0, 40, 80, 120, 200, and 280 kg/ha of K) planting densities (55 556, 41 667, and 33 333 plants/ha, spaced 0.60 m between rows and 71 428, 47 619, and 35 714 plants/ha spaced 0.70 m between rows) and N splitting on sidedressing applications (all during the planting date (PD), one-half at PD and one-half three months later;

one-third at PD; one-third two months later and one-third four months later; one-fourth at PD, one-fourth a month and a half later, one-fourth three months and one-fourth four and a half months later). The second experiment was conducted during December 1999-September 2000. The treatments tested were 2-row spacings (0.60 and 0.80 m) and six within-row spacings (0.05, 0.10, 0.15, 0.20, 0.30, and 0.40 m), displayed in a factorial 2x4. The experimental design was a complete randomized block with four replicates. The yield of fresh rhizomes increased as a result of N application from 12 130 kg/ha (0 kg/ha) to 16 124 kg/ha (130 kg/ha) and as a function of P application from 12799 kg/ha (0 kg/ha) to 15 763 kg/ha (177 kg/ha) and the splitting of N did not affect plant height and rhizome production. The yield decreased from 25 t/ha in the 0.05 m within-row spacing to 18 t/ha in the 0.40 m spacing. Productivity increase obtained from within-row spacing smaller than 0.10 m did not overcome the higher expenses with rhizomes for the respective plantings.

Medda and Hore (2003) conducted an experiment in Nadia, West Bengal, India to find out the effects of N and K at 100, 150 and 200 kg/ha each on the performance of turmeric cv. Suguna was studied. K was applied in equal splits one day before planting and at 90 days after planting (DAP). N was applied in equal splits one day before planting, and at 45 and 90 DAP. The greatest plant height (106.43 cm), number of leaves (9.73 per plant), leaf length (46.63 cm), yield per plot (9.73 kg), weight of primary fingers (165.90 g), and yield per hectare (363.75 quintal/ha) were obtained with 200 kg/ha each of N and K. The highest number of primary (6.13) and secondary (9.06) fingers per clump was recorded for 150 kg N + 100 kg and 200 kg N + 100 kg K/ha, respectively. The longest primary (7.86 cm) and secondary (5.43 cm) fingers were also obtained with 150 kg N + 200 kg K/ha. Overall, 200 kg N + 200 kg P, along with 60 kg P, was optimum for the enhancement of the yield of turmeric in the alluvial plains of West Bengal.

Thomas *et al.*, (2002) conducted a nutritional trial on turmeric (Curcuma longa L.) variety Suvarna, conducted with three levels of nitrogen (45, 60 and 75 kg ha^{-1}) and three levels of potassium (90, 120 and 150 kg ha^{-1}) at Horticulture Research

Farm, Allahabad Agricultural Institute, indicated that the growth and yield potential of the crop under Allahabad agro climatic condition can be increased by applying NPK at the rate of 75:60:150 kg ha^{-1}.

Yamgar *et al.* (2001) conducted a field experiment was conducted in Maharashtra, India, from 1988-89 to 1992-93, to determine the response of turmeric cv. Krishna to N:P:K at 0:0:0, 120:60:60, 160:80:80, 200:100:100 and 240:120:120 kg/ha and different levels of N split application: 1 application at 6 weeks after planting (WAP); 2 splits at 6 and 12 WAP; 3 at 6, 12 and 18 WAP; and 4 at 6, 12, 18 and 24 WAP. N:P:K at 200:100:100 kg/ha resulted in the maximum plant height (109 cm), number of leaves (9.8/plant), leaf length (62.8 cm), green rhizome yield (0.53 g/plant). This N:P:K rate also resulted in the highest net return (Rs. 30227/ha) and benefit cost ratio (1.62). Split application of N was better compared to one time application. N applied in 3 splits recorded the highest rhizome yield, maximum net returns and benefit:cost ratio.

Meenakshi *et al.* (2001) conducted a study was in Karnataka, India [date not given] to determine the effect of planting material and phosphorus (P) and potassium (K) nutrition on the yield and quality of turmeric cv. Cuddapah. Treatments comprised: two planting materials (mother rhizomes and fingers) and five levels of P and K (100:100, 80:80, 60:60, 40:40 and 0:0 kg/ha). Mother rhizomes recorded the highest yield (13.64 t/ha). Among the fertilizers, the highest yield (15.57 t/ha) was recorded upon treatment with P and K at 100:100 kg/ha. Mother rhizomes recorded the highest curing percentage (21.14) and cured rhizome yield (2.91 t/ha). Fertilizers also had significant effect on curing percentage and cured rhizome yield. Maximum curing percentage (22.07) and cured rhizome yield (3.44) were obtained upon treatment with the highest levels of P and K fertilizers. The highest curcumin content of 3.13% was observed in the mother rhizome, and among the fertilizer levels, the highest rate recorded the maximum curcumin content (3.41%). The interaction effects of planting material and P and K nutrition were non-significant with respect to yield, curing percentage and cured rhizome yield, but were significant for curcumin content and thereby maximum curcumin content of 3.64% was obtained in mother rhizome with P and K at 100:100 kg/ha.

Meerabai *et al.* (2000) conducted a two year field study in Kerala, India on turmeric intercropped under partial hade of coconut. They noticed that turmeric responded to higher nitrogen (N) and potassium (K) fertilizer application rates than recommended for open field conditions. Application of 120 kg N and 120 kg K_2O/ha gave the maximum economic yield.

Patra (1998) conducted an experiment with turmeric cv. PTS 9 on a sandy loam soil at G. Udayagiri, India. It was sown in a raised seed bed before the onset of rain and supplied with different rates of N, P and K fertilizers. He reported that rhizome yield and plant growth were increased consistently as the application rates of N, P and K were increased, but all treatments significantly increased yield an yield components compared to the control. The highest yields were recorded with N: P: K at 90: 60: 90, 120: 60: 90 and 90: 30: 60 kg/ha (25.5, 25.0 and 24.5 t/ha, respectively).

Venkatesha *et al.* (1998) revealed that in experiments in the kharif (monsoon) seasons of 1991 and 1992 at Bangalore, India, 2 turmeric cultivars were given 5 rates of NPK fertilizer in addition to 25 t/ha FYM. N, P and K uptake were similar I the two cultivars in 1992 but N and P uptake were higher in cv. Co-1 than in cv. Banglore local in 1991. In 1991, N, P and K uptake were highest following application of 150 kg N+125 kg P + 250kg k/ha but in 1992 they were highest following the application of the highest NPK rate (200kg N + 178 Kg P + 300 kg K/ha).

Haroon *et al.* (1997) found in a field study on farmers fields in Kushtia, Bangladesh in 1991-93, *Calocasia esculenta* cv. Meherchandi that yield decreased as the NPK rate was decreased from the usual farmer rate of 185 : 190 : 40 kg N : P_2O_5 : K_2O/ha, but marginal rate of return was increased.

Behura an Swain (1997) carried out a field trial with *Dioscoria alata* at Keonjhar, Orissa, India with 0, 50, 100, 150 kg N and 0, 60, 120, 180 kg K_2O/ha. They mentioned that tuber yield was increased with up to 100 kg N and 60 kg K_2O per hectare.

Verma *et al.* (1996) carried out an experiment at Kumarganj, India with 16 treatments consisting of combinations of 0, 40, 80 and 120 kg/ha of N and K respectively and cormel yield and nutrient uptake were evaluated. No effect was recorded between nitrogen and potash levels and days required for emergence of 50% corm. Increasing levels of nitrogen had positive effect on plant height, suckers per plant and leaves per plant.

Sheshagiri and Uthaiah (1994) investigated the yield of *Curcuma longa* cv in Karnataka, India in relation to different rates of NPK fertilizer. They reported that growth parameters and rhizome yields were significantly influenced by fertilizer application. The best growth and yield of *Curcuma longa* were observed at an NPK rate of 120:60:120 kg/ha.

Yamgar and Pawar (1991) conducted an experiment in Maharashta, India on turmeric with seven fertilizer treatments which were applied with different sources and rates of NPK (kg/ha N: P_2O_5: K_2O) as follows: 60:40:40, 45:30:30 and 120:60:60 (recommended dose) as conventional fertilizers, 60:40:40 and 45:30:30 as suphalas, and 60:40:40 and 45:30:30 as low chloride (17:17:17) complex fertilizer. Highest mean yield (140.28 q/ha) was obtained with 120:60:60 kg NPK/ha. Application of NPK as conventional fertilizer resulted in higher yields than the low chloride complex fertilizer or suphala.

Nair and Mohankumar (1991) conducted a field trial at Thiruvananthapuran India and observed that increasing levels of N (150 kg/ha) an K (150 kg/ha) tended to increase the dry matter content of 5.14 and 6.20 $g/m^{2/}$day respectively in elephant foot yam.

Mohanahumar *et al.* (1990a) conducted a trial in 1984-85 on sandy clay loam soil at vellayani, Kerala, India, Colocasia esculenta was given 40-120 kg N, 25-75 kg P_2O_5 and 50-150 kg K_2O/ha. Application of 80 kg N, 25 kg P_2O_6 and 100 kg K_2O/ha was recommended for higher cormels yield. From the study they suggested that under the agro-climatic conditions of humid tropics with medium level of available N, P and K content in the soil of fertilizer dose of 30 kg nitrogen, 25 kg P_2O_5 and 150 kg K_2O/ha with three split applications of nitrogen and potassium would be the economic optimum level of fertilizer recommendation for taro.

Mohankumar and Sadanandan (1990b) studied with three levels of N, P, K and two time f application of N and K on taro (*Colocasia esculenta* L. Schott.) at Vellayani, Kerala, India. They found total uptake of nitrogen was increased significantly only up to 80 kg/ha, but increasing levels of phosphorus and potassium application had significant effect on the uptake of these nutrients at all levels tried.

Sen and Roychoudhury (1988) conducted a field trial at Kalyani, India to study the effect of application of 40, 80 and 120 kg N and 40, 80 and 120 kg K/ha on cormel yield of Colocasia esculenta. Maximum yield of cormel (17.87 t/ha) were obtained when 120 kg N was applied. K at 80 kg/ha had given significantly higher yields than 40 kg/ha but no change was occurred at more K input. Significantly higher yields were obtained for 120 kg N/ha at all K rates compared with lower N rates. Similar results were found by (1993) and Reust (1995).

Maity *et al.* (1988) conducted an experiment at Kalyani, Wet Bengal, India to study the influence of planting time, size of rhizome as planting material, mulching materials and various levels of N, P and K on the growth and yield of ginger. They reported that the optimum fertilizer rates were N at 120, P_2O_5 at 60 and K_2O at 90 kg per ha.

CHAPTER III

MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

To find out the influence of eye number on a seed and potassium on growth and yield of turmeric the study was conducted in the field of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from April 2008 to April 2009. The materials and methods that were used and followed for conducting the experiment were presented in this chapter under the following headings-

3.1 Experimental site

The present experiment was carried out in the Farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh. The location of the experimental site is $23^0 74^{\prime}$N latitude and $90^0 35^{\prime}$E longitude and at an elevation of 8.2 m from sea level (Anon., 1989).

3.2 Characteristics of soil

The soil of the experimental area belongs to the Modhupur Tract (UNDP, 1988) under AEZ No. 28. It had shallow red brown terrace soil. The selected plot was medium high land and the soil series was Tejgaon (FAO, 1988). The characteristics of the soil under the experimental plot were analyzed in the Soil Testing Laboratory, SRDI Khamarbari, Dhaka and details of the recorded soil characteristics were presented in Appendix I.

3.3 Weather condition of the experimental site

The climate of experimental site was under the subtropical climate, characterized by three distinct seasons, the monsoon or the rainy season from November to February and the pre-monsoon or hot season from March to April and the monsoon period from May to October (Edris *et al.*, 1979). Details of the meteorological data related to the temperature, relative humidity, rainfall and sunshine during the period of the experiment was collected from the Bangladesh Meteorological Department, Agargoan, Dhaka and presented in Appendix II.

3.4 Planting materials

In this research work the local turmeric variety was collected from savar, Dhaka for planting purpose.

3.5 Treatment of the experiment

The experiment consisted of two factors. Details were presented below:

Factor A: Three levels of number of eye in each rhizome

i. E_1: Consists of one (1) eye

ii. E_2: Consists of two (2) eyes

iii. E_3: Consists of three (3) eyes

Factor B: Four levels of potassium

i. K_0: 0 kg K_2O/ha

ii. K_1: 90 kg K_2O/ha

ii. K_2: 110 kg K_2O/ha

iii. K_3: 130 kg K_2O/ha

There were 12 (3 × 4) treatments combination such as E_1K_0, E_1K_1, E_1K_2, E_1K_3, E_2K_0, E_2K_1, E_2K_2, E_2K_3, E_3K_0, E_3K_1, E_3K_2 and E_3K_3.

3.6 Design and layout of the experiment

The two factors experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. An area 30.5 m × 11.5 m was divided into three equal blocks. The layout of the experiment was prepared for distributing the treatments combination in the individual plot of each block. Each block was divided into 12 plots where 12 treatments combination were allotted at random. There were 36 unit plots altogether in the experiment. The size of the each plot was 2.5 m × 2.0 m. The distance maintained between two blocks and two plots were 1.0 m and 0.5 m respectively. The distances between row to row and plant to plant were 50 cm and 25 cm, respectively. The layout of the experiment is shown in Figure 1.

E_1 E_2 E_3

Plate 1. Photograph showing rhizome consisting of (E_1) one eye, (E_2) two eyes and (E_3) three eyes

3.7 Land preparation

The plot selected for conducting the experiment was opened in the first week of April 2008 with a power tiller, and left exposed to the sun for a week. After one week the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain until good tilth. Weeds and stubbles were removed, and finally obtained a desirable tilth of soil was obtained for planting turmeric rhizomes. The experimental plot was partitioned into unit plots in accordance with the design mentioned in Figure 1. Well-decomposed cowdung manure and nitrogen, phosphorous, potassium, gypsum, zinc oxide chemical fertilizers as indicated Table 1 were mixed with the soil of each unit plot for optimum growth and development of plant.

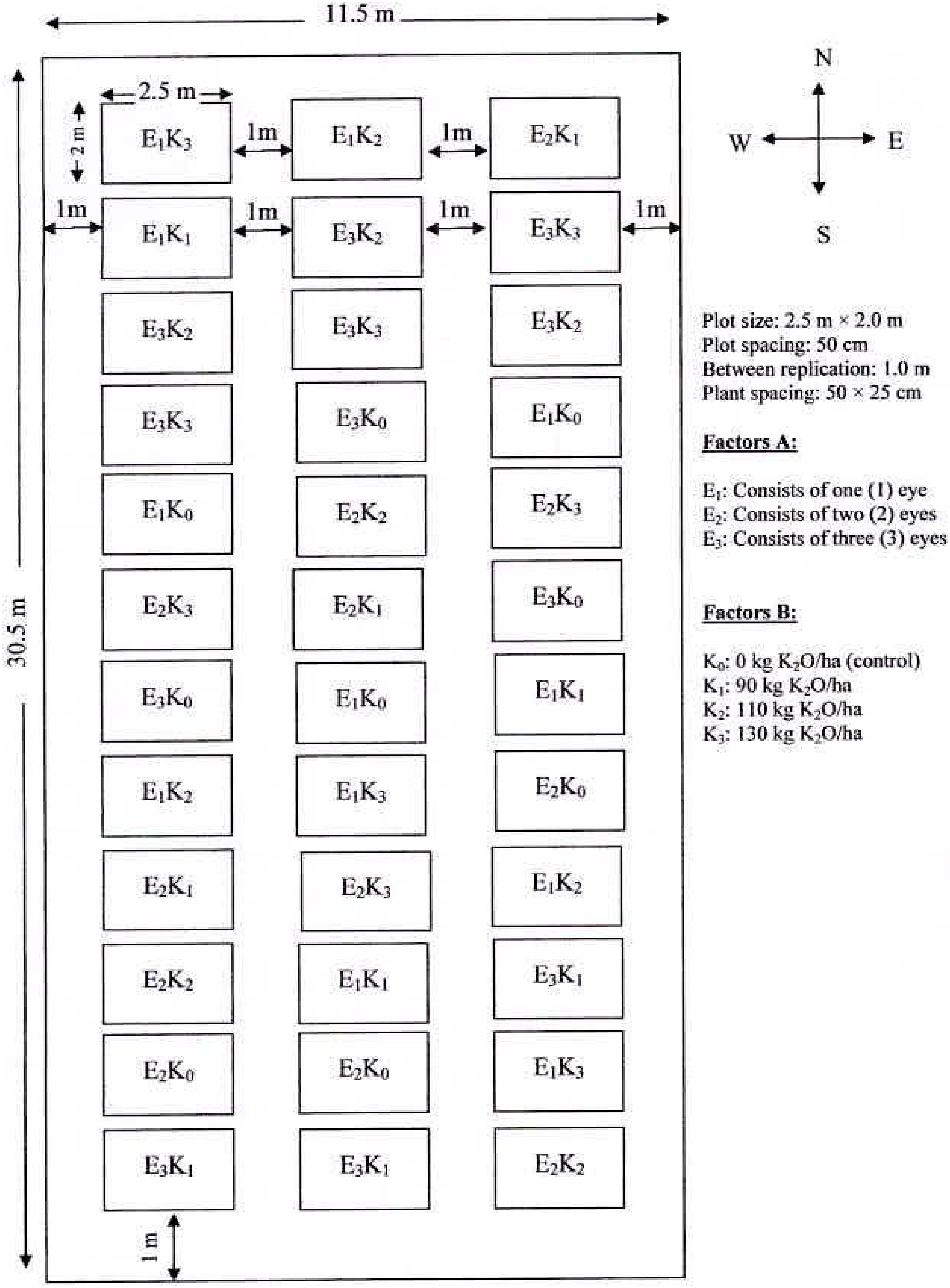


Figure 1. Layout of the experimental plot

3.8 Application of manure and fertilizers

Nitrogen, phosphorus and potash were applied in the form of urea, TSP and MP. Well-rotten cowdung, TSP (entire) MP (entire) and urea, (50% of the total amount) were applied during final land preparation. Urea was applied in two equal installments at 90 DAP and 120 DAP of turmeric rhizomes/fingers. All fertilizers were applied in accordance with treatment. The following manures and fertilizers were used as recommended by Rashid (1993) (Table 1).

Table 1. Dose and method of application of fertilizers in turmeric field

Fertilizers	Dose/ha	Application (%)		
		Basal	90 DAP	120 DAP
Cowdung	6 tons	100	--	--
Urea	240 kg	50	25	25
TSP	190 kg	100	--	--
MP	As per treatment	100	--	--
Gypsum	120 kg	100	--	--
Zinc oxide	3 kg	100	--	--

3.9 Planting of seed rhizomes

Turmeric cultivar var. local was planted on 12 May, 2008. Rhizomes/fingers were planted maintaining 50 × 25 cm spacing between and within the rows (Aiyadurai, 1966). The seed rhizomes/fingers were planted at a depth of 7.5-8.0 cm (Sastri, 1950)

3.10 Intercultural operation

Weeding was done periodically whenever necessary. Earthing up was doe three times throughout the whole growing period. The first earthing up was done after 50 days of planting. The second earthing up was dome after 90 and 120 DAP. The crop was grown under rain-fed condition.

3.11 Plant protection

For controlling insect skipper, malathion was applied 2 times at an interval of 15 days starting from soon after the appearance of infestation. Fungicides Bavistin and Rovral were applied for controlling leaf spot diseases.

3.12 Harvesting

The crop was harvested on 08 April, 2009 when the leaves turned yellow and started drying up.

3.13 Collection of data

Data were collected on different yield contributing characters and yield. The plants of the outer two rows and the extreme ends of the middle rows were excluded to avoid the border effect. Ten plants were randomly selected from each plot record data on the following parameters.

3.13.1 Emergence of seed rhizome

Emergence was recorded at an interval of 3 days starting from the commencement of the completion of 80% emergence.

3.13.2 Plant height

The height of the tallest petiole over the ground was considered as the height of the main plant and was recorded in cm at an interval of 30 days starting from 60 days after planting.

3.13.3 Number of leaves per clump

The unfurled, green and yellowish leaves were counted as leaves at an interval of 30 days starting from 60 days after planting.

3.13.4 Number of tillers per clump

The number of tillers per clump was recoded at the maximum vegetative growth stage.

3.13.5 Leaf length

Ten plants were selected from each plot and 3 leaves viz. large, medium and small per plant were used for measurement. It was measured in centimeter (cm) with the help of meter scale.

3.13.6 Leaf breadth

Ten plants were selected from each plot and 3 leaves viz. large, medium and small per plant were used for measurement. It was measured in centimeter (cm) with the help of meter scale.

3.13.7 Weight of mother rhizome

The weight of fresh mother rhizome was measured with the help of a balance at the time of harvest and was expressed in gram.

3.13.8 Number of primary fingers

The number of primary finger rhizomes per selected clump was recorded at harvest.

3.13.9 Weight of primary fingers

The weight of fresh primary fingers was measured with the help of a balance at the time of harvest and was expressed in gram.

3.13.10 Number of secondary fingers

The number of secondary finger rhizomes per selected clump was recorded at harvest.

3.13.11 Weight of secondary fingers

The weight of fresh secondary finger rhizomes was measured with the help of a balance at the time of harvest and was expressed in gram.

3.13.12 Yield of fresh rhizome per plot

The yield of all plants in each unit plot was recorded with the help of a balance at the time of harvest and was expressed in kilogram.

3.13.13 Yield of fresh rhizome per hectare

The recorded yield of fresh rhizomes per plot was converted into per hectare yield from the average yield of rhizomes per plot and was expressed in ton.

3.14 Statistical analysis

The data obtained for different characters were statistically analyzed to find out the significance of the difference for number of eyes and potassium on yield and yield contributing characters of turmeric. The mean values of all the recorded characters were evaluated and analysis of variance was performed by the 'F' (variance ratio) test. The significance of the difference among the treatment combinations of means was estimated by Duncan's Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

3.15 Economic analysis

The cost of production was analyzed in order to find out the most economic treatment of number of eyes and potassium. All input cost included the cost for lease of land and interests on running capital in computing the cost of production. The interests were calculated @ 13% in simple rate. The market price of turmeric was considered for estimating the cost and return. Analyses were done according to the procedure of Alam *et al.* (1989). The benefit cost ratio (BCR) was calculated as follows:

$$\text{Benefit cost ratio} = \frac{\text{Gross return per hectare (Tk.)}}{\text{Total cost of production per hectare (Tk.)}}$$

CHAPTER IV

RESULTS AND DISCUSSION

CHAPTER IV
RESULTS AND DISCUSSION

The experiment was carried out to determine the influence of eye number on a seed and potassium on growth and yield of turmeric. Data on different germination, yield contributing characters and yield was recorded. The analyses of variance (ANOVA) of the data are presented in Appendix III-VI. The results have been presented and discussed, and possible interpretations have been made under the following sub-headings:

4.1 Emergence of seed rhizome

Emergence of seed rhizome of turmeric had significant influence due to different number of eyes on a seed (Appendix III). For all types of number of eyes plant emerged about 80% with 40 days. In case of 20% emergence of plant highest 15 days was required for 2 and 3 number of eyes of a seed. For 40% and 60% emergence highest 22 days and 32 were required for 2 eyes seed (Table 2).

Potassium significantly influenced the emergence of seed rhizomes. In case of control condition plant required the minimum days for 20, 40, 60 and 80% emergence of seedling compare to the application of potassium and the highest doses of potassium required the highest days for emergence of seedlings. In control condition 13, 18, 26 and 34 days were required for 20%, 40%, 60% and 80% emergence. On the other hand 17, 24, 34 and 43 days was required for 20%, 40%, 60% and 80% emergence for 130 kg K_2O/ha (Table 2). From the data it was revealed that with the increase of potassium days required for emergence also increases.

Combined effect of number of eyes of a seed and levels of potassium showed significant differences. Treatment combination of E_2K_3 (consists 2 eyes of a seed with130 kg K_2O/ha) required the highest 18, 26, 36 and 44 days for 20%, 40%, 60% and 80% germination, respectively. On the other hand E_2K_0 (consists 2 eyes of a seed with 0 kg K_2O/ha) required the lowest 11, 16, 24 and 32 days for 20%, 40%, 60% and 80% germination, respectively (Table 3).

Table 2. Effect of number of eyes and different levels of potassium on days required for emergence in turmeric

Treatment	Days required for emergence			
	20%	40%	60%	80%
Number of eyes				
E_1	14.00	21.00 b	31.00 b	40.00
E_2	15.00	22.00 a	32.00 a	40.00
E_3	15.00	21.00 b	31.00 b	40.00
$LSD_{(0.05)}$	--	0.992	0.779	--
Level of significance	NS	*	*	NS
Level of potassium				
K_0	13.00 c	18.00 c	26.00 c	34.00 c
K_1	15.00 b	22.00 b	32.00 b	41.00 b
K_2	15.00 b	23.00 b	33.00 b	42.00 a
K_3	17.00 a	24.00 a	34.00 a	43.00 d
$LSD_{(0.05)}$	1.241	1.223	0.889	1.206
Level of significance	**	**	**	**
CV(%)	8.50	5.81	9.93	6.09

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

E_1 : Consists of 1 eye
E_2 : Consists of 2 eyes
E_3 : Consists of 3 eyes

K_0 : 0 kg K_2O/ha (control)
K_1 : 90 kg K_2O/ha
K_2 : 110 kg K_2O/ha
K_3 : 130 kg K_2O/ha

4.2 Plant height

Statistically significant variation was recorded on plant height of turmeric due to different number of eyes of a seed at 60, 90, 120, 150, 180, 210 and 240 DAP (Appendix IV). At the different days after planting (above mentioned DAP) the tallest plant (9.14, 32.80, 57.22, 87.32, 158.86, 105.87 and 77.71 cm) was recorded from E_2 (consists of 2 eyes of a seed) whereas, at the same DAP the shortest plant (8.39, 30.66, 53.25, 83.66, 146.31, 100.71 and 75.16 cm) was recorded from E_1 (consists of 1 eye of a seed), respectively (Table 4). It was revealed that with the increases of DAP, the plant height showed a increasing trend thereafter showed decreasing trend. Two eyes seeds were more effective for the increasing of plant height. This finding also similar with the findings of Pirjade *at al.* (2007).

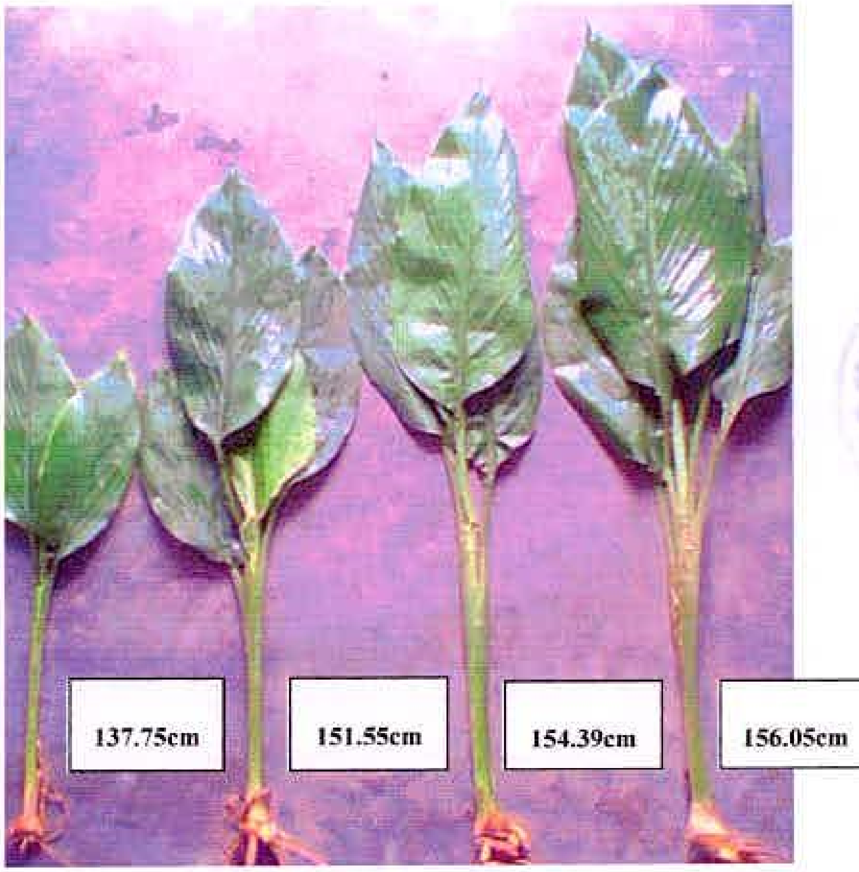
Plant height of turmeric differed significantly due to the application of different level of potassium at days after planting of 60, 90, 120, 150, 180, 210 and 240 DAP (Appendix IV). At 60, 90, 120, 150, 180, 210 and 240 DAP the tallest plant (10.02 cm, 33.76 cm, 62.44 cm, 92.11 cm, 156.05 cm, 118.86 cm and 87.69 cm) was observed from K_3 treatment (130 kg K_2O/ha) which was statistically identical (9.05, 32.78 cm, 59.86 cm, 91.55 cm, 154.39 cm, 117.09 cm and 84.31 cm) with K_2 (110 kg K_2O/ha), respectively.

Again, the shortest plant (7.40, 27.68, 40.16, 67.56, 137.75, 65.98 and 56.35 cm) was found from K_0 as control for the same DAP, respectively (Table 4). It was revealed that plant height increased with the increased days after planting and also revealed that the plant height increased with the increased in potassium. Potassium fertilizer ensured favorable condition for the growth of turmeric with optimum cell division and elongation of cell and the ultimate results was the tallest plant. May *et al.* (2005) reported that plant height increased with increasing K rates. Medda and Hore (2003) recorded highest plant height (106.43 cm from 200 kg/ha K.

Table 3. Interaction effect of number of eyes and different level of potassium on days required for emergence of turmeric

Treatment	Days required for emergence			
	20%	40%	60%	80%
E_1K_0	13.00 cd	18.00 f	27.00 d	36.00 d
E_1K_1	14.00 bc	22.00 cde	32.00 c	41.00 bc
E_1K_2	14.00 bc	22.00 bcde	32.00 c	40.00 c
E_1K_3	16.00 ab	23.00 abcd	33.00 bc	42.00 abc
E_2K_0	11.00 d	16.00 f	24.00 e	32.00 e
E_2K_1	15.00 bc	24.00 abc	33.00 bc	41.00 bc
E_2K_2	17.00 ab	24.00 ab	35.00 ab	43.00 ab
E_2K_3	18.00 a	26.00 a	36.00 a	44.00 a
E_3K_0	14.00 bc	20.00 e	28.00 d	34.00 de
E_3K_1	15.00 bc	21.00 de	32.00 c	41.00 bc
E_3K_2	15.00 bc	21.00 cde	33.00 c	43.00 abc
E_3K_3	17.00 ab	22.00 bcd	33.00 bc	43.00 abc
$LSD_{(0.05)}$	2.150	2.119	1.557	2.090
Level of significance	*	**	*	**
CV(%)	8.50	5.81	9.93	6.09

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability



K_0 K_1 K_2 K_3

Plate 2: Photograph showing different plant height at different levels of potassium

K_0 = 98.44 g K_1 = 133.29 g K_2 = 135.0 g K_3 = 135.59 g

Plate 3: Photograph showing different weight of finger at different levels of potassium

Combined effect of number of eyes of a seed and level of potassium showed statistically significant variation on plant height in turmeric at 60, 90, 120, 150, 180, 210 and 240 DAP (Appendix IV). The tallest plant (11.08, 36.21, 67.68, 96.33, 168.73, 126.64 and 93.66 cm) was recorded from E_2K_3 (consists of 2 eyes of a seed with 130 kg K_2O/ha) at 60, 90, 120, 150, 180, 210 and 240 DAP, respectively whereas the shortest plant (7.54, 26.99, 40.94, 66.73, 134.07, 65.57 and 58.79 cm) was obtained from E_1K_0 (consist of 1 eye of a seed with 0 kg K_2O/ha) at 60, 90, 120, 150, 180, 210 and 240 DAP, respectively (Table 5).

4.3 Number of leaves per clump

Number of leaves per clump of turmeric showed statistically significant variation due to different number of eyes of a seed at 60, 90, 120, 150, 180, 210 and 240 DAP (Appendix V). At different days after planting (DAP) the maximum number of leaves per clump (6.83, 11.47, 16.97, 20.52, 24.00, 22.38 and 19.05) was recorded from E_2 (consists of 2 eyes of a seed) whereas, at the same DAP the minimum number of leaves per clump (4.64, 10.19, 16.11, 19.11, 22.31, 21.12 and 17.88) was obtained from E_1 (consists of 1 eye of a seed), respectively (Table 6). It was revealed that two eyes seeds were more effective for the increasing of number of leaves per clump. Number of leaves showed decreasing trend after a certain day that may be due to ripening of leaves. Maia *et al.* (1995) reported that turmeric plants originating from primary rhizomes with 2-3 numbers of eyes had a greater number of leaves.

Table 4. Effect of number of eyes and different level of potassium on plant height of turmeric

Treatment	Plant height (cm) at						
	60 DAP	90 DAP	120 DAP	150 DAP	180 DAP	210 DAP	240 DAP
Number of eyes							
E_1	8.39 b	30.66 b	53.25 b	83.66 c	146.31 b	100.71	75.16
E_2	9.14 a	32.80 a	57.22 a	87.32 a	158.86 a	105.87	79.31
E_3	8.70 ab	31.16 b	54.43 ab	85.24 b	144.63 b	102.76	77.71
$LSD_{(0.05)}$	0.550	1.408	3.047	1.459	4.915	NS	NS
Level of significance	*	*	*	*	**	--	--
Level of potassium							
K_0	7.40 c	27.68 c	40.16 c	67.56 c	137.75 b	65.98 c	56.35 c
K_1	8.52 b	31.94 b	57.41 b	90.41 b	151.55 a	110.52 b	81.22 b
K_2	9.05 b	32.78 ab	59.86 ab	91.55 a	154.39 a	117.09 a	84.31 ab
K_3	10.02 a	33.76 a	62.44 a	92.11 a	156.05 a	118.86 a	87.69 a
$LSD_{(0.05)}$	0.635	1.626	3.518	1.872	5.675	6.193	4.028
Level of significance	**	**	**	**	**	**	**
CV(%)	7.43	5.27	8.55	11.80	9.87	6.14	10.32

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

Table 5. Interaction effect of number of eyes and different levels of potassium on plant height in turmeric

Treatment	Plant height (cm) at						
	60 DAP	90 DAP	120 DAP	150 DAP	180 DAP	210 DAP	240 DAP
E_1K_0	7.54 f	26.99 e	40.94 de	66.73 de	134.07 f	65.57 de	58.79 d
E_1K_1	8.14 ef	31.12 cd	54.95 c	88.53 c	148.14 cde	107.61 c	77.63 c
E_1K_2	8.44 cdef	31.65 cd	56.68 c	89.30 c	150.36 cd	113.37 bc	79.98 c
E_1K_3	9.44 bcd	32.88 bcd	60.42 bc	90.07 bc	152.69 bc	116.30 abc	84.22 bc
E_2K_0	6.22 g	26.22 e	36.50 e	63.75 e	138.32 ef	56.34 e	50.38 e
E_2K_1	9.18 bcde	33.60 abc	60.20 bc	93.50 abc	161.74 ab	115.54 abc	83.85 bc
E_2K_2	10.09 ab	35.16 ab	64.51 ab	95.71 ab	166.66 a	124.95 ab	89.35 ab
E_2K_3	11.08 a	36.21 a	67.68 a	96.33 a	168.73 a	126.64 a	93.66 a
E_3K_0	8.43 cdef	29.82 d	43.05 d	72.19 d	140.86 def	76.03 d	59.89 d
E_3K_1	8.23 def	31.10 cd	57.07 c	89.19 c	144.76 cde	108.41 c	82.17 bc
E_3K_2	8.61 cdef	31.53 cd	58.39 bc	89.63 c	146.15 cde	112.96 bc	83.59 bc
E_3K_3	9.54 bc	32.20 bcd	59.22 bc	89.93 bc	146.73 cde	113.64 bc	85.20 bc
$LSD_{(0.05)}$	1.100	2.816	6.093	5.496	9.829	10.73	6.977
Level of significance	**	*	*	**	*	**	**
CV(%)	7.43	5.27	8.55	11.80	9.87	6.14	10.32

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

Due to the application of different level of potassium number of leaves per clump of turmeric differed significantly at days after planting of 60, 90, 120, 150, 180, 210 and 240 DAP (Appendix V). At 60, 90, 120, 150, 180, 210 and 240 DAP the maximum number of leaves per clump (6.33, 11.96, 18.89, 21.90, 26.07, 23.79 and 21.13) was observed from K_3 (130 kg K_2O/ha) which was statistically identical (6.03, 11.96, 18.59, 20.72, 25.12, 22.52 and 19.48) with K_2 (110 kg K_2O/ha), respectively. Again, the minimum (3.56, 7.30, 9.00, 15.85, 17.51, 17.82 and 15.38) was found from K_0 as control for the same DAP, respectively (Table 6). It was revealed that with the increase of potassium number of leaves per clump increases upto a certain days than decreases. Optimum level of potassium produced the maximum number of leaves per clump by ensuring appropriate essential nutrients. Medda and Hore (2003) recorded highest number of leaves (9.73 per plant from 200 kg/ha K.

A statistically significant variation was recorded due to combined effect of number of eyes of a seed and levels of potassium on number of leaves per clump of turmeric at 60, 90, 120, 150, 180, 210 and 240 DAP (Appendix V). The maximum number of leaves per clump (8.56, 13.78, 20.67, 23.73, 27.66, 25.53 and 22.82) was recorded from E_2K_3 (consists of 2 eyes of a seed with 130 kg K_2O/ha) at 60, 90, 120, 150, 180, 210 and 240 DAP, respectively whereas the minimum number of leaves per clump (3.11, 5.78, 7.56, 14.38, 16.13, 16.23 and 12.75) was found from E_2K_0 (consist of 2 eye of a seed with 0 kg K_2O/ha) at 60, 90, 120, 150, 180, 210 and 240 DAP, respectively (Table 7).

4.4 Number of tillers per clump

Due to different number of eyes of a seed number of tillers per clump of turmeric showed statistically significant differences (Appendix VI). The maximum number of tillers per clump (5.59) was observed from E_2 (consists of 2 eyes of a seed) whereas, the minimum number of tillers per clump (4.15) was obtained from E_1 (consists of 1 eye of a seed), which was statistically similar (4.18) to E_3 as consists of 3 eyes of a seed (Figure 2).

It was revealed that two eyes seeds were more effective for the increasing of number of tillers per clump whereas 1 and 3 eyes were less effective for number of tillers per clump. Singh and Prasad (2006) also reported similar results.

Number of tillers per clump of turmeric differed significantly due to the application of different level of potassium (Appendix VI). The maximum number of tillers per clump (5.44) was recorded from K_3 (130 kg K_2O/ha) which was statistically identical (5.09) with K_2 (110 kg K_2O/ha), respectively. Again, the minimum (3.22) was found from K_0 as control which was closely followed (4.82) by K_1 as 90 kg K_2O/ha (Figure 3). It was revealed that with the increase of potassium number of tillers per clump increases.

Significant variation was recorded due to combined effect of number of eyes of a seed and level of potassium on number of tillers per clump in turmeric (Appendix VI). The maximum number of tillers per clump (7.04) was obtained from E_2K_3 (consists of 2 eyes of a seed with 130 kg K_2O/ha) whereas the minimum number of tillers per clump (2.88) was recorded from E_2K_0 as consist of 2 eyes of a seed + 0 kg K_2O/ha (Table 9).

4.5 Leaf length

Leaf length of turmeric showed statistically non significant variation due to different number of eyes of a seed (Appendix VI). The highest leaf length (68.13 cm) was observed from E2 (consists of 2 eyes of a seed) whereas, the lowest leaf length (63.43 cm) was recorded from E1 as consists of 1 eye of a seed (Table 8). It was revealed that two eyes seeds were more effective for longest leaf whereas 1 and 3 eyes were less effective for leaf length. Govinden and Cheong (1995) reported similar findings.

Table 6. Effect of number of eyes and different level of potassium on number of leaves per clump of turmeric

Treatment	Number of leaves per clump (cm) at						
	60 DAP	90 DAP	120 DAP	150 DAP	180 DAP	210 DAP	240 DAP
Number of eyes							
E_1	4.64 b	10.19 b	16.11 ab	19.11 b	22.31 b	21.12 b	17.88
E_2	6.83 a	11.47 a	16.97 a	20.52 a	24.00 a	22.38 a	19.05
E_3	4.56 b	10.31 b	15.31 b	19.37 b	23.56 a	21.17 b	18.74
$LSD_{(0.05)}$	0.913	0.862	1.163	1.093	1.224	1.060	--
Level of significance	**	**	*	*	*	*	NS
Level of potassium							
K_0	3.56 b	7.30 b	9.00 b	15.85 c	17.51 c	17.82 c	15.38 d
K_1	5.44 a	11.41 a	18.04 a	20.20 b	24.45 b	22.09 b	18.23 c
K_2	6.03 a	11.96 a	18.59 a	20.72 ab	25.12 ab	22.52 b	19.48 b
K_3	6.33 a	11.96 a	18.89 a	21.90 a	26.07 a	23.79 a	21.13 a
$LSD_{(0.05)}$	1.054	0.995	1.343	1.262	1.413	1.223	1.243
Level of significance	**	**	**	**	**	**	**
CV(%)	20.18	9.55	8.52	6.56	6.21	11.81	6.85

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

Table 7. Interaction effect of number of eyes and different level of potassium on number of leaves per clump of turmeric

Treatment	Number of leaves per clump (cm) at						
	60 DAP	90 DAP	120 DAP	150 DAP	180 DAP	210 DAP	240 DAP
E_1K_0	3.44 bc	7.00 e	10.55 c	15.26 e	16.73 e	17.52 f	15.73 e
E_1K_1	4.78 bc	11.11 bc	17.56 b	19.68 cd	23.54 c	21.67 cde	17.46 de
E_1K_2	5.11 bc	11.34 bc	18.11 ab	20.12 bcd	23.91 c	21.93 bcde	18.20 cd
E_1K_3	5.22 b	11.33 bc	18.22 ab	21.38 abc	25.07 abc	23.35 abcd	20.13 bc
E_2K_0	3.11 c	5.78 e	7.56 d	14.38 e	16.13 e	16.23 f	12.75 f
E_2K_1	7.22 a	12.67 ab	19.22 ab	21.63 abc	25.47 abc	23.57 abc	19.16 bcd
E_2K_2	8.43 a	13.67 a	20.45 a	22.35 ab	26.72 ab	24.17 ab	21.48 ab
E_2K_3	8.56 a	13.78 a	20.67 a	23.73 a	27.66 a	25.53 a	22.82 a
E_3K_0	4.11 bc	9.11 d	8.89 cd	17.90 d	19.67 d	19.71 e	17.66 de
E_3K_1	4.33 bc	10.44 cd	17.34 b	19.30 cd	24.35 bc	21.03 de	18.07 cd
E_3K_2	4.56 bc	10.89 bcd	17.22 b	19.69 cd	24.74 bc	21.48 cde	18.78 cd
E_3K_3	5.22 b	10.78 bcd	17.78 b	20.60 bc	25.48 abc	22.48 bcd	20.44 bc
$LSD_{(0.05)}$	1.825	1.724	2.326	2.186	2.447	2.119	2.153
Level of significance	0.01	0.01	0.05	0.01	0.05	0.01	0.01
CV(%)	20.18	9.55	8.52	6.56	6.21	11.81	6.85

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

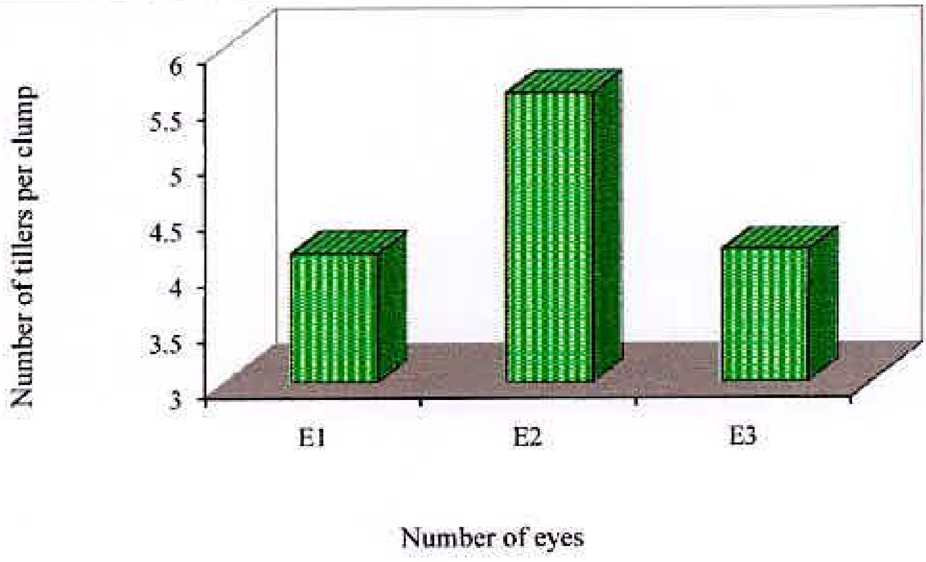


Figure 2. Effect of number of eyes on the number of tillers per clump of turmeric

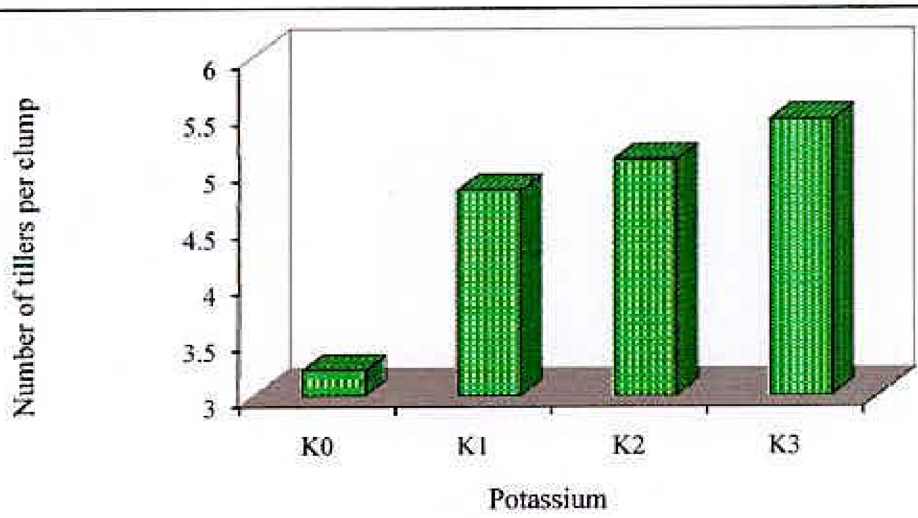


Figure 3. Effect of different level of potassium on the number of tillers per clump of turmeric

Leaf length of turmeric differed significantly due to the application of different levels of potassium (Appendix VI). The highest leaf length (74.81 cm) was observed from K_2 (110 kg K_2O/ha) and the lowest (53.13 cm) was observed from K_0 as control (Table 8). It was revealed that potassium helps for optimum vegetative growth that ensured maximum leaf length in highest amount. Medda and Hore (2003) recorded highest leaf length (46.63 cm) from 200 kg/ha K from their earlier experiment.

Combined effect of number of eyes of a seed and levels of potassium varied non-significantly on leaf length in turmeric (Appendix VI). The highest leaf length (75.75 cm) was found from E_2K_3 (consists of 2 eyes of a seed with 130 kg K_2O/ha) whereas; the lowest leaf length (50.50 cm) was obtained from E_3K_0 as consist of 3 eyes of a seed with 0 kg K_2O/ha (Table 9).

4.6 Leaf breadth

Statistically significant variation was recorded for leaf breadth of turmeric due to different number of eyes of a seed (Appendix VI). The highest leaf breadth (18.24 cm) was observed from E_3 (consists of 3 eyes of a seed) whereas, the lowest leaf breadth (15.79 cm) was found from E_1 (consists of 1 eye of a seed) which was statistically similar (16.75 cm) to E_2 as consists of 2 eyes of a seed (Table 8). Similar findings also reported by Singh and Prasad (2006).

Table 8. Effect of number of eyes and different level of potassium on yield contributing characters in turmeric

Treatment	Leaf length (cm)	Leaf breadth (cm)	Primary finger		Secondary finger		Yield (t/ha)
			Number	Weight (g)	Number	Weight (g)	
Number of eyes							
E_1	63.43	15.79 b	8.93	123.01 b	18.77 c	63.62 b	22.70 b
E_2	68.13	16.75 b	9.54	128.43 a	22.41 b	69.07 a	24.58 a
E_3	65.49	18.24 a	8.86	125.32 ab	23.81 a	62.88 b	22.31 b
$LSD_{(0.05)}$	--	1.029	--	3.947	0.571	1.991	0.674
Level of significance	NS	**	NS	*	**	**	**
Level of potassium							
K_0	53.13 c	14.27 c	7.76 c	98.44 b	19.99 d	59.89 b	15.14 c
K_1	66.53 b	16.55 b	8.95 b	133.30 a	20.94 c	65.89 a	24.77 b
K_2	74.81 a	19.33 a	9.66 ab	135.02 a	22.30 b	67.13 a	26.07 a
K_3	68.25 b	17.55 b	10.07 a	135.59 a	23.41 a	67.89 a	26.31 a
$LSD_{(0.05)}$	5.763	1.188	0.762	4.557	0.659	2.299	0.778
Level of significance	0.01	0.01	0.01	0.01	0.01	0.01	0.01
CV(%)	8.97	7.18	8.56	5.71	8.11	9.61	7.43

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

Table 9. Interaction effect of number of eyes and different level of potassium on yield contributing characters of turmeric

Treatment	Number of tillers per clump	Leaf length (cm)	Leaf breadth (cm)	Weight of mother rhizome per clump (g)	Primary finger(s)		Secondary finger(s)		Yield	
					Number	Weight (g)	Number	Weight (g)	kg/plot	ton/hectare
E_1K_0	3.13 d	57.81	13.43	97.76 c	7.84 de	97.21 d	15.40 g	58.29 f	7.45 g	14.89g
E_1K_1	4.14 bc	65.53	15.22	110.40 b	8.81 cd	130.66 b	18.23 f	64.41 cde	12.15 ef	24.31 ef
E_1K_2	4.54 bc	70.81	18.00	111.76 b	9.47 bc	131.67 b	20.30 e	65.37 cd	12.67 cde	25.34 cde
E_1K_3	4.79 b	59.55	16.50	113.44 b	9.60 bc	132.51 b	21.13 de	66.39 bc	13.14 cd	26.28 cd
E_2K_0	2.88 d	51.09	14.17	91.70 c	6.65 e	92.51 d	21.80 cd	60.14 ef	7.56 g	15.12 g
E_2K_1	6.15 a	66.25	16.58	116.45 ab	9.68 bc	138.34 ab	22.47 bc	70.32 ab	13.26 bc	26.51 bc
E_2K_2	6.30 a	79.42	19.04	119.95 a	10.60 ab	141.12 a	21.73 cd	72.46 a	13.93 ab	27.85 ab
E_2K_3	7.04 a	75.75	17.22	120.67 a	11.22 a	141.77 a	23.63 b	73.36 a	14.41 a	28.82 a
E_3K_0	3.65 cd	50.50	15.22	94.16 c	8.79 cd	105.61 c	22.77 bc	61.24 def	7.71 g	15.41 g
E_3K_1	4.18 bc	67.82	17.85	110.63 b	8.35 cd	130.90 b	22.13 cd	62.94cde	11.74 f	23.49 f
E_3K_2	4.43 bc	74.21	20.95	110.83 b	8.91 cd	132.28 b	24.87 a	63.54 cde	12.51 de	25.01 de
E_3K_3	4.48 bc	69.44	18.92	110.67 b	9.40 bc	132.49 b	25.47 a	63.80 cde	12.67 cde	25.34 cde
$LSD_{(0.05)}$	0.896	--	--	6.129	1.320	7.893	1.142	3.982	0.675	1.348
Level of significance	0.01	NS	NS	0.05	0.01	0.01	0.01	0.05	0.01	0.01
CV(%)	11.39	8.97	7.18	12.32	8.56	5.71	8.11	9.61	7.43	7.43

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

Leaf breadth of turmeric varied significantly due to the application of different levels of potassium (Appendix VI). The highest leaf breadth (19.33 cm) was recorded from K_2 (110 kg K_2O/ha) which was closely followed (17.55 cm and 16.55 cm) by K_3 (130 kg K_2O/ha) and K_1 (90 kg K_2O/ha), respectively. The lowest (14.27 cm) was observed from K_0 as control (Table 8). It was revealed that leaf breadth increased with the increased of potassium level due to optimum cell elongation.

A statistically non significant difference was recorded due to combined effect of number of eyes of a seed and level of potassium on leaf breadth in turmeric (Appendix VI). The highest leaf breadth (20.95 cm) was found from E_3K_2 (consists of 3 eyes of a seed with 110 kg K_2O/ha) whereas the lowest leaf breadth (13.43 cm) was recorded from E_1K_0 as consist of 1 eye of a seed with 0 kg K_2O/ha (Table 9).

4.7 Weight of mother rhizome per clump

Weight of mother rhizome per clump of turmeric showed statistically significant variation due to different number of eyes of a seed (Appendix VI). The highest weight of mother rhizome per clump (112.19 g) was recorded from E_2 (consists of 2 eyes of a seed) whereas, the lowest weight of mother rhizome per clump (106.57 g) was recorded from E_3 (consists of 3 eyes of a seed) which was statistically similar (108.34 g) with E_1 as consists of 1 eye of a seed (Figure 4).

Weight of mother rhizome per clump of turmeric differed significantly due to the application of different level of potassium (Appendix VI). The highest weight of mother rhizome per clump (114.94 g) was recorded from K_3 (130 kg K_2O/ha) which was statistically identical (114.18 g and 112.50 g) to K_2 (110 kg K_2O/ha) and K_1 (90 kg K_2O/ha), respectively.The lowest (94.54 g) was found from K_0 as control (Figure 5). It was revealed that weight of mother rhizome increased with the increased in potassium. Potassium fertilizer ensured maximum plant nutrients in available from which help proper growth of plant and the results are the highest weight of mother rhizome.

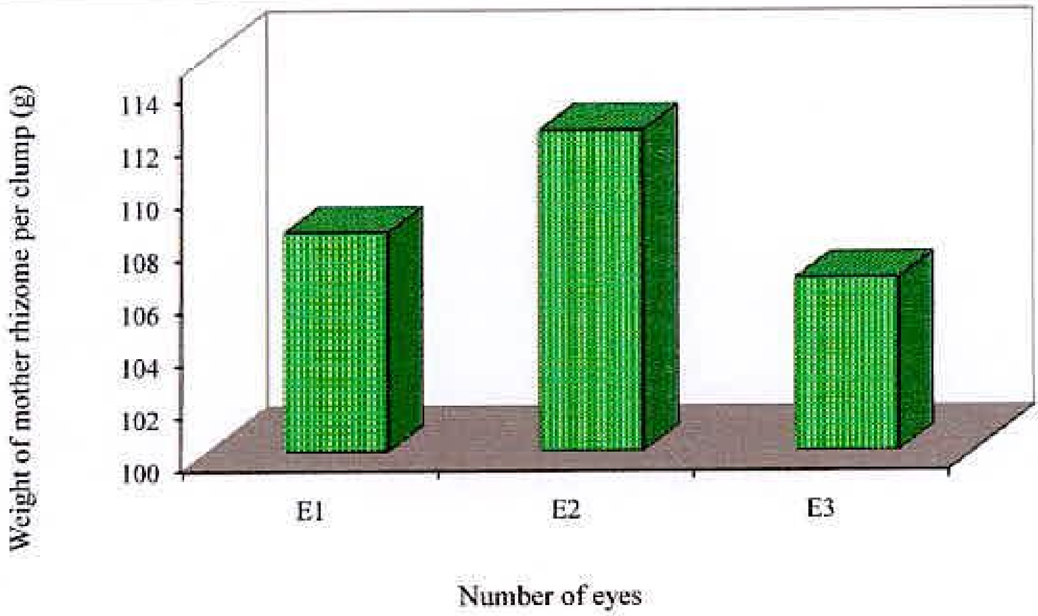


Figure 4. Effect of number of eyes on weight of mother rhizome per clump of turmeric

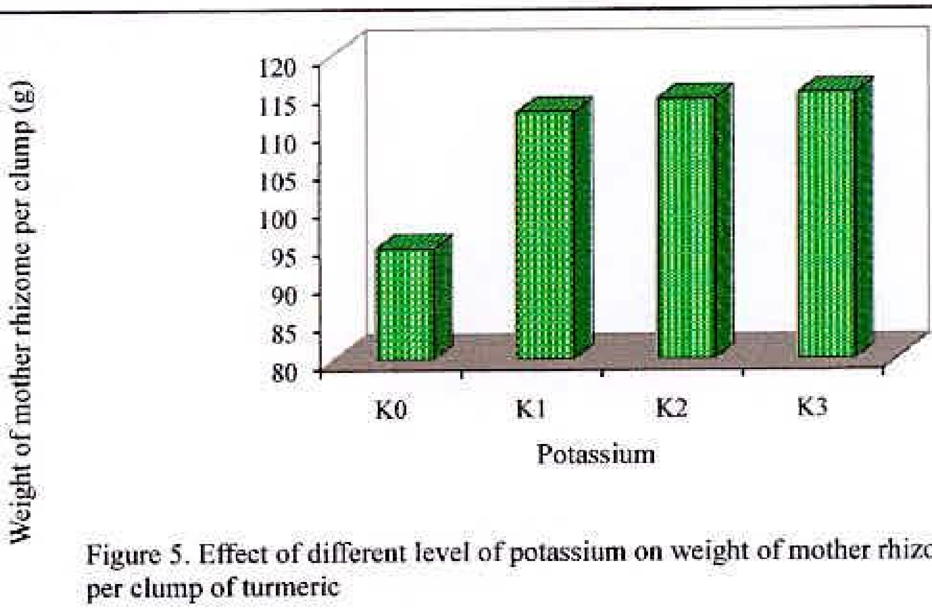


Figure 5. Effect of different level of potassium on weight of mother rhizome per clump of turmeric

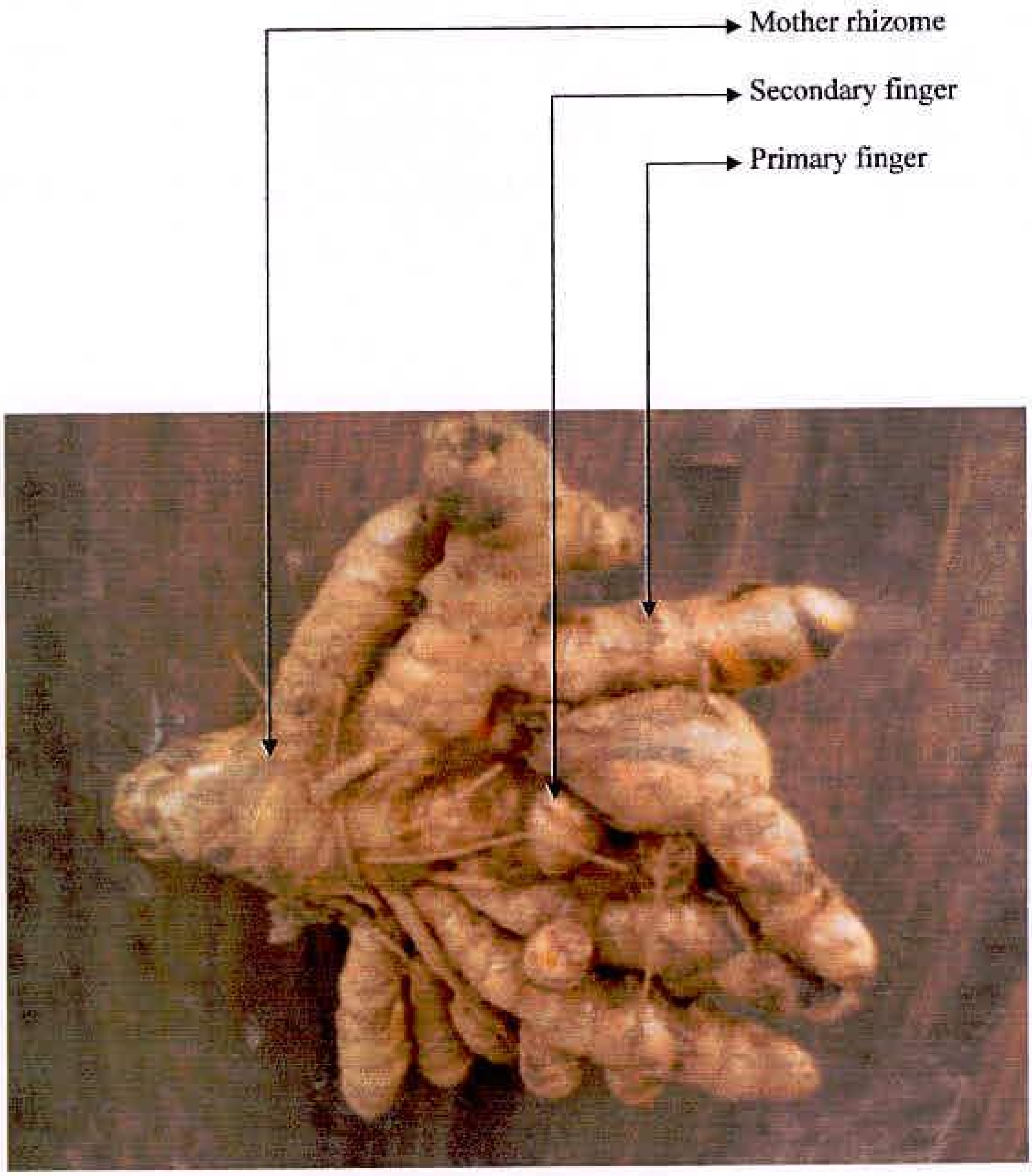


Plate 4. Photograph showing mother rhizome, primary and secondary finger

Significant variation was recorded due to interaction effect of number of eyes of a seed and levels of potassium on weight of mother rhizome per clump in turmeric (Appendix VI). The highest weight of mother rhizome per clump (120.67 g) was found from E_2K_3 (consists of 2 eyes of a seed with 130 kg K_2O/ha) whereas the lowest weight of mother rhizome per clump (91.70 g) was obtained from E_2K_0 as consist of 2 eyes of a seed with 0 kg K_2O/ha (Table 9).

4.8 Number of primary finger per clump

Due to different number of eyes of a seed number of primary finger per clump of turmeric varied non-significantly (Appendix VI). The maximum number of primary fingers per clump (9.54) was obtained from E_2 (consists of 2 eyes of a seed) whereas, the lowest number of primary finger per clump (8.86) was found from E_3 as consists of 3 eyes of a seed (Table 8). Govinden and Cheong (1995) reported similar findings.

Statistically significant variation was recorded for number of primary finger per clump of turmeric due to the application of different level of potassium (Appendix VI). The highest number of primary fingers per clump (10.07) was recorded from K_3 (130 kg K_2O/ha) which was statistically identical (9.66) to K_2 (110 kg K_2O/ha).The lowest (7.76) was observed from K_0 as control (Table 8).

Combined effect of number of eyes of a seed and levels of potassium varied on number of primary finger per clump in turmeric (Appendix VI). The highest number of primary fingers per clump (11.22) was observed from E_2K_3 (consists of 2 eyes of a seed with 130 kg K_2O/ha) whereas the lowest number of primary finger per clump (7.84) was recorded from E_1K_0 as consist of 1 eye of a seed with 0 kg K_2O/ha (Table 9).

E_1 E_2 E_3

Plate 5: Photograph showing different plant height at different level of eyes

E_1 = 123.01 g

E_3 = 125.32 g

E_2 = 128.43 g

Plate 6: Photograph showing different finger weight of different level of eyes

4.9 Weight of primary fingers per clump

Weight of primary finger per clump of turmeric showed statistically significant variation due to different number of eyes of a seed (Appendix VI). The highest weight of primary finger per clump (128.43 g) was recorded from E_2 (consists of 2 eyes of a seed) whereas, the lowest weight of primary finger per clump (123.01 g) was recorded from E_1 (consists of 1 eye of a seed) which was statistically similar (125.34 g) with E_3 as consists of 3 eyes of a seed (Table 8). These findings are agreed with the findings of Singh and Prasad (2006).

Weight of primary finger per clump of turmeric differed significantly due to the application of different levels of potassium (Appendix VI). The highest weight of primary fingers per clump (135.59 g) was recorded from K_3 (130 kg K_2O/ha) which statistically identical (135.02 g and 133.30 g) to K_2 (110 kg K_2O/ha) and K_1 (90 kg K_2O/ha), respectively. Again, the lowest (98.44 g) was observed from K_0 as control (Table 8). It was revealed that the gross yield increased with the increased in potassium.

A statistically significant difference was recorded due to interaction effect of number of eyes of a seed and level of potassium on weight of primary fingers per clump in turmeric (Appendix VI). The highest weight of primary finger per clump (141.77 g) was observed from E_2K_3 (consists of 2 eyes of a seed with 130 kg K_2O/ha) whereas; the lowest weight of primary fingers per clump (97.21 g) was found from E_1K_0 as consist of 1 eye of a seed with 0 kg K_2O/ha (Table 9).

4.10 Number of secondary finger per clump

Statistically significant variation was recorded for number of secondary finger per clump of turmeric due to different number of eyes of a seed (Appendix VI). The maximum number of secondary fingers per clump (23.81) was obtained from E_3 (consists of 3 eyes of a seed) which was closely followed (22.41) by E_2 (consists of 2 eyes of a seed) whereas, the lowest number of secondary finger per clump (18.77) was recorded from E_1 as consists of 1 eye of a seed (Table 8). Yoyhasiri *et al.* (1997) also recorded the relevant findings.

Number of secondary fingers per clump of turmeric differed significantly due to the application of different levels of potassium (Appendix VI). The highest number of secondary finger per clump (23.41) was found from K_3 (130 kg K_2O/ha) and the lowest (19.99) was observed from K_0 (control) which was closely followed (20.94) by K_1 (90 kg K_2O/ha) (Table 8). Similar trends of results also reported by Patra (1998).

A statistically significant difference was recorded due to combined effect of number of eyes of a seed and levels of potassium on number of secondary finger per clump in turmeric (Appendix VI). The highest number of secondary finger per clump (25.47) was observed from E_3K_3 (consists of 3 eyes of a seed with 130 kg K_2O/ha) whereas the lowest number of secondary finger per clump (15.40) was found from E_1K_0 as consist of 1 eye of a seed with 0 kg K_2O/ha (Table 9).

4.11 Weight of secondary fingers per clump

Weight of secondary finger per clump of turmeric showed statistically significant variation due to different number of eyes of a seed (Appendix VI). The highest weight of secondary finger per clump (69.07 g) was observed from E_2 (consists of 2 eyes of a seed) whereas, the lowest (62.88 g) was recorded from E_3 (consists of 3 eyes of a seed) which was statistically similar (63.62 g) with E_1 as consists of 1 eye of a seed (Table 8). Govinden and Cheong (1995) reported similar findings.

Due to the application of different levels of potassium weight of secondary fingers per clump in turmeric varied significantly (Appendix VI). The highest weight of secondary finger per clump (67.85 g) was found from K_3 (130 kg K_2O/ha) which statistically identical (67.13 g and 65.89 g) to K_2 (110 kg K_2O/ha) and K_1 (90 kg K_2O/ha), respectively. The lowest (59.90 g) was observed from K_0 as control (Table 8).

A statistically significant difference was recorded due to combined effect of number of eyes of a seed and level of potassium for weight of secondary finger per clump of turmeric (Appendix VI). The highest weight of secondary fingers per clump (73.36 g) was observed from E_2K_3 (consists of 2 eyes of a seed with 130 kg

K_2O/ha) whereas the lowest weight of secondary finger per clump (58.29 g) was recorded from E_1K_0 as consist of 1 eye of a seed with 0 kg K_2O/ha (Table 9).

4.12 Yield per plot

Yield per plot of turmeric showed statistically significant variation due to different number of eyes of a seed (Appendix VI). The highest yield per plot (12.29 kg) was recorded from E_2 (consists of 2 eyes of a seed) whereas, the lowest yield per plot (11.16 kg) was found from E_3 (consists of 3 eyes of a seed) which was statistically similar (11.35 kg) with E_1 as consists of 1 eye of a seed (Figure 6). Maia *et al.* (1995) reported that turmeric plants originating from primary rhizomes with 2-3 number of eyes had a highest yield of new rhizomes (up to 50% more), than plants produced from secondary rhizomes with 2-3 eyes.

Yield per plot of turmeric differed significantly due to the application of different level of potassium (Appendix VI). The highest yield per plot (13.40 kg) was found from K_3 (130 kg K_2O/ha) which statistically identical (13.03 kg) with K_2 (110 kg K_2O/ha) and closely followed (12.38 kg) by K_1 (90 kg K_2O/ha) which the lowest yield per plot (7.57 kg) was observed from K_0 as control (Figure 7). It was revealed that the gross yield increased with the increased in potassium.

A statistically significant difference was recorded due to combined effect of number of eyes of a seed and level of potassium for yield per plot (Appendix VI). The highest yield per plot (14.41 kg) was observed from E_2K_3 (consists of 2 eyes of a seed with 130 kg K_2O/ha) whereas the lowest yield per plot (7.45 kg) was recorded from E_1K_0 as consist of 1 eye of a seed with 0 kg K_2O/ha (Table 9).

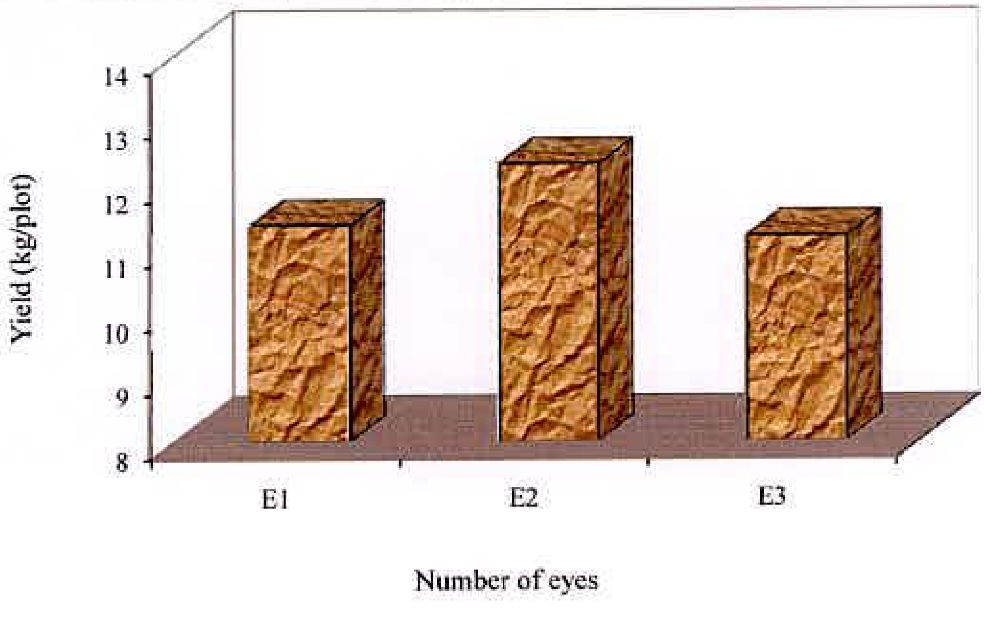


Figure 6. Effect of number of eyes on yield per plot of turmeric

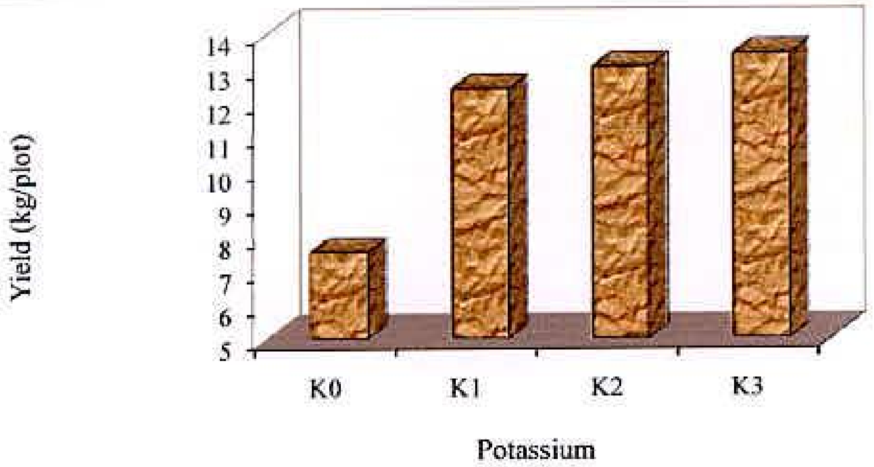


Figure 7. Effect of different level of potassium on yield per plot of turmeric

4.13 Yield per hectare

Statistically significant variation was recorded for yield per hectare of turmeric due to different number of eyes of a seed (Appendix VI). The highest yield per hectare (24.58 ton) was observed from E_2 (consists of 2 eyes of a seed) whereas, the lowest yield per hectare (22.31 ton) was obtained from E_3 (consists of 3 eyes of a seed) which was statistically similar (22.70 ton) with E_1 as consists of 1 eye of a seed (Table 8). Yoyhasiri *et al.* (1997) reported similar findings earlier.

Yield per hectare of turmeric differed significantly due to the application of different level of potassium (Appendix VI). The highest yield per hectare (26.81 ton) was obtained from K_3 (130 kg K_2O/ha) which statistically identical (26.07 ton) to K_2 (110 kg K_2O/ha) and closely followed (24.77 ton) by K_1 (90 kg K_2O/ha). The lowest yield per hectare (15.14 ton) was observed from K_0 as control (Table 8). Potassium improves root system of turmeric, so that the roots can absorb the minerals and irons from soil solution efficiently, resulting with higher yield. Pirjade *at al.* (2007) reported similar results from their experiment. Medda and Hore (2003) recorded highest yield per hectare (363.75 quintal/ha) from 200 kg/ha K from their experiment.

Combined effect of number of eyes of a seed and level of potassium showed statistically significant variation in respect of yield per hectare (Appendix VI). The highest yield per hectare (28.82 ton) was found from the treatment combination of E_2K_3 (consists of 2 eyes of a seed with 130 kg K_2O/ha) whereas the lowest yield per hectare (14.89 ton) was observed from E_1K_0 as consist of 1 eye of a seed with 0 kg K_2O/ha (Table 9).

4.14.1 Economic analysis

Input costs for land preparation, rhizome cost, fertilizer, irrigation and manpower required for all the operations from planting to harvesting of turmeric were recorded for unit plot and converted into cost per hectare. Price of turmeric was considered as per market rate. The economic analysis presented under the following headings-

Table 10. Cost and return of turmeric cultivation as influenced by number of eyes and different level of potassium

Treatment Combination	Cost of production (Tk./ha)	Yield of Turmeric (t/ha)	Gross return (Tk./ha)	Net return (Tk./ha)	Benefit cost ratio
E_1K_0	216449	14.89	297800	81351	1.38
E_1K_1	226060	24.31	486200	260140	2.15
E_1K_2	228196	25.34	506800	278604	2.22
E_1K_3	230331	26.28	525600	295269	2.28
E_2K_0	216449	15.12	302400	85951	1.40
E_2K_1	226060	26.51	530200	304140	2.35
E_2K_2	228196	27.85	557000	328804	2.44
E_2K_3	230331	28.82	576400	346069	2.50
E_3K_0	216449	15.41	308200	91751	1.42
E_3K_1	226060	23.49	469800	243740	2.08
E_3K_2	228196	25.01	500200	272004	2.19
E_3K_3	230331	25.34	506800	276469	2.20

4.14.2 Gross return

The combination of number of eyes of a seed and level of potassium showed different gross return. The highest gross return (Tk. 576,400/ha) was found from E_2K_3 (consists of 2 eyes with 130 kg K_2O/ha) and the second highest gross return (Tk. 557,000/ha) was found in E_2K_2 (consists of 2 eyes with 110 kg K_2O/ha). The lowest gross return (Tk. 297800/ha) was obtained from E_1K_0 (consists of 1 eyes with 0 kg K_2O/ha) (Table 10).

4.14.3 Net return

In case of net return different treatment combination showed different concentration of net return. The highest net return (Tk. 346,069/ha) was found from E_2K_3 and the second highest net return (Tk. 328,804/ha) was obtained from E_2K_2. The lowest (Tk. 81351/ha) net return was obtained E_1K_0 (Table 10).

4.14.4 Benefit cost ratio

In the combination of number of eyes on a seed and level of potassium highest benefit cost ratio (2.50) was noted from E_2K_3 and the second highest benefit cost ratio (2.44) was estimated from E_2K_2. The lowest benefit cost ratio (1.38) was obtained from E_1K_0 (Table 10). From economic point of view, it was apparent from the above results that the combination of E_2K_3 was more profitable than rest of the combination.

CHAPTER V

SUMMARY AND CONCLUSION

Chapter V
SUMMARY AND CONCLUSION

The study was conducted at the Horticultural Farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from April 2008 to April 2009 to find out the influence of eye number on a seed and potassium on growth and yield of turmeric. Factor A: Three levels of number of eye in each rhizome; E_1: Consists of one (1) eye; E_2: two (2) eyes and E_3: three (3) eyes and Factor B: Four levels of potassium; K_0: 0 kg; K_1: 90 kg; K_2: 110 kg and K_3: 130 kg K_2O/ha respectively. The experiment was laid out following Randomized Complete Block Design (RCBD) with three replications.

For all types of number of eyes 80% plant emerged about at 40 days. In control condition 13, 18, 26 and 34 days were required for 20, 40, 60 and 80% emergence. On the other hand 17, 24, 34 and 43 days was required for 20, 40, 60 and 80% emergence. Treatment combination of E_2K_3 required highest (18, 26, 36 and 44 days) for 20%, 40%, 60% and 80% germination, respectively. On the other hand E_2K_0 required lowest (11, 16, 24 and 32 days) for 20, 40, 60 and 80% germination, respectively.

The tallest plant (11.08 cm, 36.21 cm, 67.68 cm, 96.33 cm, 168.73 cm, 126.64 cm and 93.66 cm) was recorded from E_2K_3 whereas the shortest plant (7.54 cm, 26.99 cm, 40.94 cm, 66.73 cm, 134.07 cm, 65.57 cm and 58.79 cm) was obtained from E_1K_0. The maximum number of leaves per clump (8.56, 13.78, 20.67, 23.73, 27.66, 25.53 and 22.82) was recorded from E_2K_3 whereas the minimum (3.11, 5.78, 7.56, 14.38, 16.13, 16.23 and 12.75) was found from E_1K_0. The maximum number of tillers per clump (7.04) was obtained from E_2K_3 where the minimum (2.88) was recorded from E_2K_0. The highest leaf length (68.13 cm) was observed from E_2 whereas the lowest (63.43 cm) was recorded from E_1. The highest leaf length (74.81 cm) was observed from K_3 and the lowest (53.13 cm) was observed from K_0. The highest leaf length (75.75 cm) was found from E_2K_3 whereas the lowest (50.50 cm) was obtained from E_3K_0.

The highest leaf breadth (20.95 cm) was found from E_3K_2 where the lowest (13.43 cm) was recorded from E_1K_0. The highest weight of mother rhizome per clump (112.19 g) was recorded from E_2 whereas the lowest (106.57 g) was recorded from E_3. The highest weight of mother rhizome per clump (114.93 g) was recorded from K_3 again, the lowest (94.54 g) was found from K_0 as control. The highest weight of mother rhizome per clump (120.67 g) was found from E_2K_3 where the lowest (91.70 g) was obtained from E_2K_0.

The highest weight of primary finger per clump (141.12 g) was observed from E_2K_3 where as the lowest (92.51g) was found from E_2K_0. The highest number of secondary finger per clump (25.47) was observed from E_3K_3 whereas the lowest number (15.40) was found from E_1K_0. The highest weight of secondary finger per clump (73.36 g) was observed from E_2K_3 whereas the lowest (58.29 g) was recorded from E_1K_0. The highest yield per hectare (24.58 ton) was observed from E_2 whereas the lowest (22.31 ton) was obtained from E_3. The highest yield per hectare (26.81 ton) was obtained from K_3 again, the lowest (15.14 ton) was observed from K_0. The highest yield per hectare (28.82 ton) was found from E_2K_3 whereas the lowest (14.89 ton) was observed from E_1K_0. The highest net return (Tk. 346,069) was found from E_2K_3 and the lowest (Tk. 81351) net return was obtained E_1K_0. The highest benefit cost ratio (2.50) was noted from E_2K_3 and the lowest (1.38) was obtained from E_1K_0. From economic point of view, it was apparent from the above results that the combination of E_2K_3.

Conclusion:

Considering the situation of the present experiment, further studies in the following areas may be suggested:

- Such study is needed in different agro-ecological zones (AEZ) of Bangladesh for regional compliance and other performance.
- Another experiment may be carried out with rhizome size and number of eyes.
- Another level of potassium may be included for further study.

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APPENDICES

APPENDICES

Appendix I. Characteristics of Horticulture Farm soil is analyzed by Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Horticulture Garden , SAU, Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled

B. Physical and chemical properties of the initial soil

Characteristics	Value
% Sand	27
% Silt	43
% clay	30
Textural class	silty-clay
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20.00
Exchangeable K (me/100 g soil)	0.10
Available S (ppm)	45

Source: SRDI

Appendix II. Monthly average record of air temperature, rainfall, relative humidity, soil temperature and Sunshine of the experimental site during the period from April 2008 to April 2009

Month	Air temperature (°c)		Relative humidity (%)	Rainfall (mm) (total)	Sunshine (hr)
	Maximum	Minimum			
April, 2008	36.9	19.6	64	91	8.5
May, 2008	36.7	20.3	70	205	7.7
June, 2008	35.4	22.5	80	577	4.2
July, 2008	34.0	24.6	83	563	3.1
August, 2008	36.0	23.6	81	319	4.0
September, 2008	34.8	24.4	81	279	4.4
October, 2008	34.8	18.0	77	227	5.8
November, 2008	32.3	16.3	69	0	7.9
December, 2008	29.0	13.0	79	0	3.9
January, 2009	28.1	11.1	72	1	5.7
February, 2009	33.9	12.2	55	1	8.7
March, 2009	34.6	16.5	67	45	7.3
April, 2009	35.8	20.3	65	88	8.3

Source: Bangladesh Meteorological Department (Climate & weather division) Agargoan, Dhaka - 1212

Appendix III. Analysis of variance of the data on days required for emergence of turmeric as influenced by number of eyes and different level of potassium

Source of variation	Degrees of freedom	Mean square			
		Days required for emergence			
		20%	40%	60%	80%
Replication	2	0.004	0.797	0.006	1.388
Number of eyes (A)	2	3.063	6.061*	3.929*	0.742
Potassium (B)	3	24.675**	60.484**	110.373**	136.025**
Interaction (A×B)	6	4.420*	7.354**	6.172**	6.017**
Error	22	1.612	1.566	0.846	1.523

**: Significant at 0.01 level of probability: *: Significant at 0.05 level of probability

Appendix IV. Analysis of variance of the data on plant height of turmeric as influenced by number of eyes and different level of potassium

Source of variation	Degrees of freedom	Mean square						
		Plant height (cm) at						
		60 DAP	90 DAP	120 DAP	150 DAP	180 DAP	210 DAP	240 DAP
Replication	2	0.069	1.034	0.667	5.100	4.048	5.115	22.549
Number of eyes (A)	2	1.714*	15.032*	50.012*	40.593*	725.934**	80.893	52.730
Potassium (B)	3	10.758**	64.650**	915.040**	1278.94**	625.036**	5631.09**	1833.83**
Interaction (A×B)	6	2.674**	9.529*	39.405*	38.477**	97.313*	182.642**	69.168**
Error	22	0.422	2.765	12.948	10.535	33.695	40.129	16.979

**: Significant at 0.01 level of probability: *: Significant at 0.05 level of probability

Appendix V. Analysis of variance of the data on number of leaves per clump of turmeric as influenced by number of eyes and different level of potassium

Source of variation	Degrees of freedom	Mean square						
		Number of leaves per clump						
		60 DAP	90 DAP	120 DAP	150 DAP	180 DAP	210 DAP	240 DAP
Replication	2	0.434	0.097	0.309	0.471	0.236	0.797	0.178
Number of eyes (A)	2	20.005**	6.014**	8.329*	6.744*	9.172*	6.061*	4.429
Potassium (B)	3	13.988**	45.766**	204.481**	62.948**	137.533**	60.484**	53.034**
Interaction (A×B)	6	4.118**	6.916**	5.734*	7.340**	5.488*	7.354**	10.618**
Error	22	1.162	1.036	1.887	1.667	2.089	1.566	1.616

**: Significant at 0.01 level of probability: *: Significant at 0.05 level of probability

Appendix VI. Analysis of variance of the data on yield contributing characters and yield of turmeric as influenced by number of eyes and different level of potassium

Source of variation	Degrees of freedom	Mean square			
		Number of tillers per clump	Leaf length (cm)	Leaf breadth (cm)	Weight of mother rhizome per clump (g)
Replication	2	0.097	42.535	0.035	13.335
Number of eyes (A)	2	8.127**	66.641	18.263**	525.156**
Potassium (B)	3	8.699**	744.418**	40.054**	4495.462**
Interaction (A×B)	6	1.821**	81.067	0.243	210.685**
Error	22	0.280	34.747	1.476	32.249

**: Significant at 0.01 level of probability: *: Significant at 0.05 level of probability

Appendix VI. Contd'

Source of variation	Degrees of freedom	Mean square					
		Primary finger		Secondary finger		Yield	
		Number	Weight (g)	Number	Weight (g)	Plot (kg)	Yield (ton)
Replication	2	0.318	1.330	1.419	3.101	0.073	0.294
Number of eyes (A)	2	1.644	88.873*	81.280**	137.241**	4.397**	17.589**
Potassium (B)	3	9.265**	2955.776**	20.342**	118.135**	66.498**	265.993**
Interaction (A×B)	6	2.786**	90.052**	4.660**	18.406*	0.580*	2.319*
Error	22	0.608	21.730	0.455	5.530	0.159	0.634

**: Significant at 0.01 level of probability: *: Significant at 0.05 level of probability

Appendix VII. Production cost of turmeric

A. Input cost

Treatment Combination	Labour cost	Ploughing cost	Seed Cost	Water for plant Establishment	Cost of Manure and fertilizers						Insecticide/ pesticides	Sub Total (A)
					Cowdung	Urea	TSP	MP	$ZnSo_4$	Gypsum		
E_1K_0	22000.00	9000.00	16000.00	6000.00	18000.00	3600.00	11400.00	0.00	360.00	2400.00	7000.00	95760.00
E_1K_1	22000.00	9000.00	16000.00	6000.00	18000.00	3600.00	11400.00	8100.00	360.00	2400.00	7000.00	103860.00
E_1K_2	22000.00	9000.00	16000.00	6000.00	18000.00	3600.00	11400.00	9900.00	360.00	2400.00	7000.00	105660.00
E_1K_3	22000.00	9000.00	16000.00	6000.00	18000.00	3600.00	11400.00	11700.00	360.00	2400.00	7000.00	107460.00
E_2K_0	22000.00	9000.00	16000.00	6000.00	18000.00	3600.00	11400.00	0.00	360.00	2400.00	7000.00	95760.00
E_2K_1	22000.00	9000.00	16000.00	6000.00	18000.00	3600.00	11400.00	8100.00	360.00	2400.00	7000.00	103860.00
E_2K_2	22000.00	9000.00	16000.00	6000.00	18000.00	3600.00	11400.00	9900.00	360.00	2400.00	7000.00	105660.00
E_2K_3	22000.00	9000.00	16000.00	6000.00	18000.00	3600.00	11400.00	11700.00	360.00	2400.00	7000.00	107460.00
E_3K_0	22000.00	9000.00	16000.00	6000.00	18000.00	3600.00	11400.00	0.00	360.00	2400.00	7000.00	95760.00
E_3K_1	22000.00	9000.00	16000.00	6000.00	18000.00	3600.00	11400.00	8100.00	360.00	2400.00	7000.00	103860.00
E_3K_2	22000.00	9000.00	16000.00	6000.00	18000.00	3600.00	11400.00	9900.00	360.00	2400.00	7000.00	105660.00
E_3K_3	22000.00	9000.00	16000.00	6000.00	18000.00	3600.00	11400.00	11700.00	360.00	2400.00	7000.00	107460.00

E_1 : Consists of 1 eye

E_2 : Consists of 2 eyes

E_3 : Consists of 3 eyes

K_0 : 0 kg K_2O/ha (control)

K_1 : 90 kg K_2O/ha

K_2 : 110 kg K_2O/ha

K_3 : 130 kg K_2O/ha

Appendix VII. Contd.

B. Overhead cost (Tk./ha)

Treatment Combination	Cost of lease of land for 12 months (13% of value of land Tk. 7,00000/year	Miscellaneous cost (Tk. 5% of the input cost	Interest on running capital for 12 months (Tk. 13% of cost/year	Sub total (Tk) (B)	Total cost of production (Tk./ha) [Input cost (A)+ overhead cost (B)]
E_1K_0	91000	4788	24901	120689	216449
E_1K_1	91000	5193	26007	122200	226060
E_1K_2	91000	5283	26253	122536	228196
E_1K_3	91000	5373	26498	122871	230331
E_2K_0	91000	4788	24901	120689	216449
E_2K_1	91000	5193	26007	122200	226060
E_2K_2	91000	5283	26253	122536	228196
E_2K_3	91000	5373	26498	122871	230331
E_3K_0	91000	4788	24901	120689	216449
E_3K_1	91000	5193	26007	122200	226060
E_3K_2	91000	5283	26253	122536	228196
E_3K_3	91000	5373	26498	122871	230331

E_1 : Consists of 1 eye

E_2 : Consists of 2 eyes

E_3 : Consists of 3 eyes

K_0 : 0 kg K_2O/ha (control)

K_1 : 90 kg K_2O/ha

K_2 : 110 kg K_2O/ha

K_3 : 130 kg K_2O/ha