STUDIES ON SEED PRODUCTION, PROCESSING, DORMANCY AND STORAGE IN BLOU BUFFEL (*Cenchrus glaucus*) cv. CO 1

Thesis submitted in part fulfilment of the requirements for the award of the Degree of ***Doctor of Philosophy (Agriculture) in Seed Science and Technology*** *to the Tamil Nadu Agricultural University, Coimbatore*

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CERTIFICATE

This is to certify that the thesis entitled **"STUDIES ON SEED PRODUCTION, PROCESSING, DORMANCY AND STORAGE IN BLOU BUFFEL (*Cenchrus glaucus*) cv. CO 1"** submitted in part fulfilment of the requirements for the award of the degree of **Doctor of Philosophy (Agriculture) in Seed Science and Technology** to the Tamil Nadu Agricultural University, Coimbatore is a record of **bonafide** research work carried out by **Mrs. R. GEETHA** under my supervision and guidance and that no part of this thesis has been submitted for the award of any other degree, diploma, fellowship or other similar titles or prizes and that the work has not been published in part or full in any scientific or popular journal or magazine.

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ABSTRACT

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STUDIES ON SEED PRODUCTION, PROCESSING, DORMANCY AND STORAGE IN BLOU BUFFEL (*Cenchrus glaucus*) cv. CO 1

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Degree : Doctor of Philosophy (Agriculture) in Seed Technology

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Studies were undertaken at the Department of Seed Science and Technology, Tamil Nadu Agricultural University, Coimbatore to elicit information on (i) the effect of dates of sowing and cutting treatments on seed yield and quality (ii) seed development and maturation (iii) the effect of tillers on seed quality (iv) the influence of temperature and media on seed germination (v) true seed extraction methods (vi) upgradation of seed quality using specific gravity separator (vii) the effect of dormancy breaking methods on germination improvement (viii) the effect of pelleting on plant establishment and (ix) the storability of seed in *Cenchrus glaucus* cv. CO 1.

Seed yield and yield components were higher in the crop sown during June 5th with no cut for fodder. Favorable weather conditions resulted in higher seed yield even with crop cut twice for fodder as evident with the crop sown on January 30th.

Germination potential of seeds was not influenced by dates of sowing but cutting treatments reduced the germination and vigour of seeds.

The physiological maturity of seeds was attained at 18 DAA accompanied by maximum dry weight, germination and vigour. Seeds in the middle and proximal one third portions of the spike contained better quality seeds than those in the distal one third portion.

Seeds from the first six tillers recorded maximum germination and vigour.

For the germination test, sand and roll towel medium are better than top of paper method at an alternate temperature range of 25-30°C.

True seeds from the fluffs could be extracted by treating the fluffs with commercial grade sulphuric acid @ 480 ml kg^{-1} of fluffs for 16 min with higher seed recovery associated with seed quality. Mechanical defluffing, although recorded higher seed recovery than acid scarification, inflicted embryo injury leading to low germination.

Specific gravity separation improved the fluff quality to a greater extend at the air flow rate of 4 with the V levels of 0 and 0.5 irrespective of the H scale adjustments.

Fluffs from first three higher level spouts consisting the heaviest fractions of fluffs and a recovery of 90 per cent could be used for sowing, since the germination of these seed grades were well above the minimum seed certification standards.

Soaking acid scarified fluffs in chemical solutions of $CuSO_4$ (50 ppm) or ascorbic acid (25 ppm) could effectively overcome the dormancy of fluffs. Soaking true seeds in $CuSO_4$ (50 ppm) or ascorbic acid (25 ppm) improved the germination to 80 per cent.

Seeds pelleted using DAP (60 g kg^{-1} of seed) either with $FeSO_4$ or $ZnSO_4$ (10 g kg^{-1} of seed) and arappu leaf powder as a filler material registered the highest dry-matter production and vigour index values. Seed germination and field emergence were the highest with $CuSO_4$ pelleted seeds.

In storage, germination of fluffs (both non scarified and scarified) improved with advancing periods of storage due to dormancy release.

Fluffs maintained germination and vigour for longer period than true seeds. Seeds / fluffs treated with halogen mixture and packed in 700 gauge polythene bag maintained germination and vigour better than untreated seeds.

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INTRODUCTION

CHAPTER I
INTRODUCTION

Agricultural economy in the arid and most of the semiarid regions in India is largely livestock based. Natural grass lands are characterized by poor productivity, the forage deficit being of the order of 40 to 60 per cent. Forage and feeds are the major inputs in animal production especially in milch animals, which account for about 60 per cent of the total cost of production. Our country supports about 15 per cent of world's livestock population, in its two per cent of the world's geographical area, which indicates the pressure of animals on land resources (Sharma *et al.*, 1999). The forages, besides as animal feed, are bound to contribute potentially towards bio remediation of degraded ecosystem and industrial uses.

Looking at the need of forage resources of the country, the estimate of fodder production from all sources is projected to be 513 million tonnes (mt) green and 400 mt dry forage as against the requirement of 1083 mt green and 676 mt dry forage for economic productivity of animals (Anon., 1997). The country has 6.9 million ha of land under cultivated fodders which accounts for 4.9 per cent of land under cultivation. The extension of area for the cultivated fodders is very difficult.

The productivity of cultivated fodder is also low because of less input use and less availability of quality seeds of improved cultivars. The sufficient number of improved cultivar is also lacking unlike arable crops. Against the estimated requirement of one lakh mt of certified fodder seed for 10 per cent replacement, the availability is hardly 20 per cent. Similarly, against the seed requirement of 25000 mt of range grasses and legumes, the availability may not exceed 10-15 per cent in each case (Anon., 1997).

Too often scientists have concentrated on improving vegetative growth and forage nutritive value and have given little attention to seed production. However, in the last 3 decades, progress has been made in improving crop husbandry and the technique of seed harvesting to get higher seed yield and better seed quality. Another important area which needs to be understand and strengthened is the post harvest aspects of seeds specially processing and storage of seeds and methods for controlling seed deterioration (Hazra and Sinha, 1996). Hence, the widely grown grass in Tamil Nadu, *Cenchrus*, which is a palatable and nutritious grass species has been selected for this study.

Cenchrus is an apomicitic grass species, which is easily established from both seed and rooted slips. *Cenchrus glaucus* (Blou buffel) cv. CO1 is a selection from the local line FS 391 released during 1989, by Tamil Nadu Agricultural University, Coimbatore. *C. glaucus* cv. CO1 is a aneuploid with a chromosomal number 2n = 42 (Rao, 1980). Blou buffel is a deep rooted perennial having erect and slender leafy culms to a height of 60-120 cm. The inflorescence are slender and 2.5-10 cm long with bristles.

It is well adopted to a wide range of soil types and can be grown both as rainfed and as irrigated crop. The yield is about 112 q ha^{-1} $year^{-1}$ as rainfed and over 560 q ha^{-1} under irrigated conditions. Forage is both palatable and nutritious. It needs 60-65 days for flowering and fodder cut. The forage is having 28 per cent dry matter, 9.06 per cent crude protein, 41.01 per cent carbohydrate, 0.58 per cent Ca, 0.26 per cent P, 385 ppm iron, 24 ppm Zn and 16 ppm of Cu, with digestibility of 49.45 per cent.

Seed production in tropical forage crops faces many more problems and limitations than in temperate species. It is mostly due to inherent characteristics of species, which include non-synchronization of flowering and maturity, production of less number of fertile seeds, low yield, low harvest index and abscission of spikelets. Flowering and seed setting largely depend upon the environmental conditions prevailing at the time of seed production.

Further expansion of area under cultivated fodder especially for seed production is difficult because of existing pressure on agricultural land for food and cash crops. Therefore, it is necessary to develop strategies for higher seed yields without cutting for

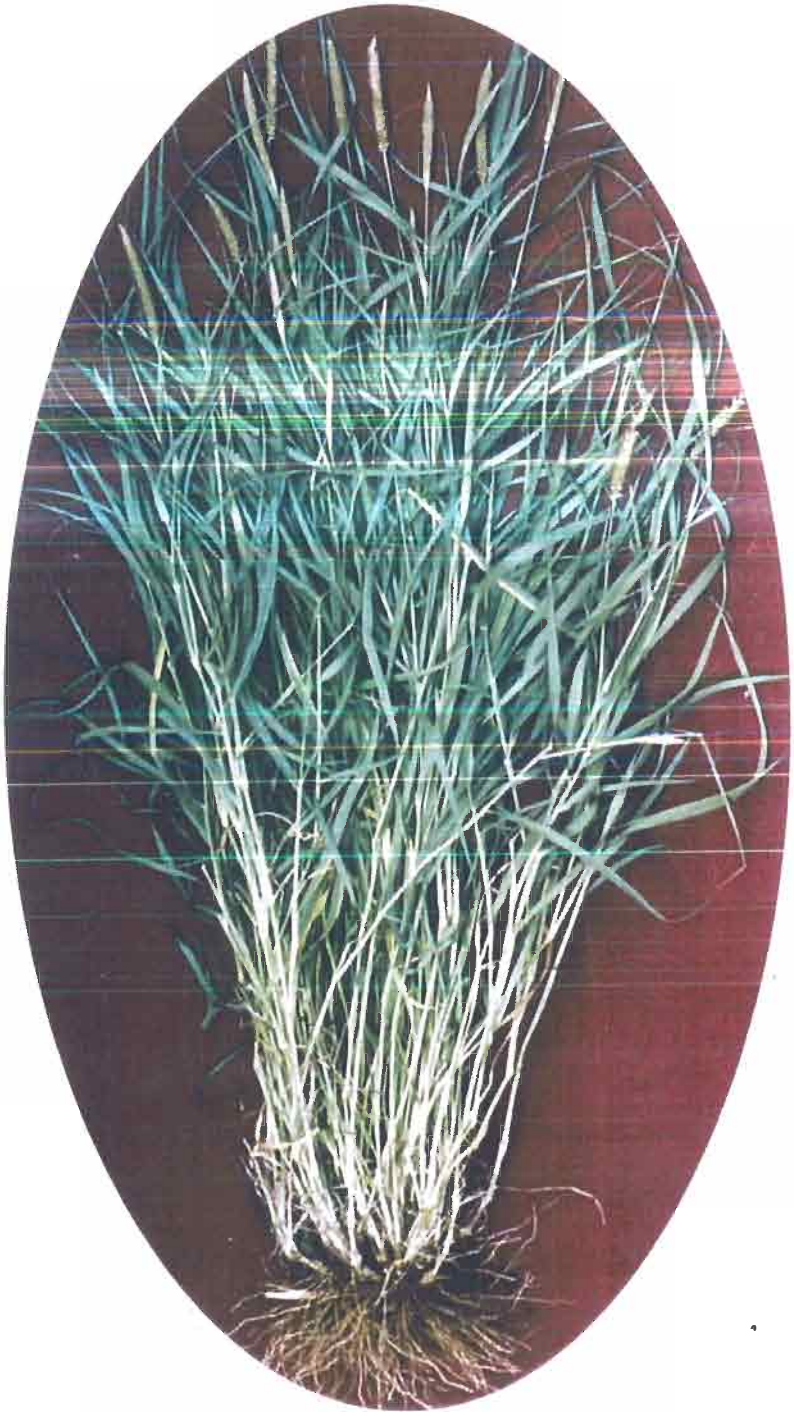


Plate 1. Blou buffel - a palatable grass

green forage and for obtaining moderate yields of green forage as well as seed from the same crop by following appropriate management techniques. With cutting management, the age of the growth and sprouting of the plants could be suitably altered in such a fashion so as to synchronise the reproductive phase with favourable photoperiod and temperature.

Seed maturity is not uniform in *Cenchrus* due to nonsynchronised tillering, flowering and maturity. The stage of maturity is an important factor responsible for variation in vigour and viability of seeds. The decision as to harvesting time is difficult to make for crops with this complex inflorescence. Hence, the knowledge on development of seeds from fertilization to maturity is valuable for better management.

Cenchrus seeds are chaffy and sold in the form of fluffs each consisting of 1–3 spikelets surrounded by wavy bristles. These chaffy seeds are light, bulky and do not flow freely, adding to the cost of seed cleaning, testing, storage and transport and making it impossible to sow the seed with conventional seeders. Trimming of chaffy seed units is preferable, leaving the protecting husk around the caryopses, which reduces the risk of physical damage during processing and improves the reliability of field establishment under marginal moisture conditions (Loch, 1993).

Once the seeds are made free flowing, then the separation of illfilled / blank seeds is possible by upgrading. Air screen cleaners are commonly used for cleaning grass seeds. They remove most of the dust particles and only a portion of immature seed units but are not capable of separating complete seed units from incomplete ones. Specific gravity separator in addition to air screen cleaner can be used to upgrade the seeds of grasses (Douglas *et al.*, 2000). In the specific gravity separator, seeds are separated by the specific gravity created by forced air and the oscillating deck movement according to density. The slope of the deck and the speed of air blow rate must be standardised for each species to get maximum benefits.

The upgraded seeds with less appendages, which flow freely can possibly be used in conjunction with improved seed coating technology to enhance the establishment (Chakravarthy and Bhati, 1969), even under problem soils (Silcock and Smith, 1982), barren lands, forest areas or range lands (Loch, 1993). In addition to adding weight to seeds, seed pelleting helps to retain moisture in soils.

In *Cenchrus*, seed germination itself is a problem and it needs post harvest period of three months before sowing. The photo period during maturity is important in *Cenchrus*, since seed dormancy varies with flowering time (Sharif-Zadeh and Murdoch, 2000). Dormancy breaking methods will be important for immediate sowing of fresh seeds.

Apart from spikelet sowing, under assured soil moisture conditions, caryopses (true seeds) can easily be sown since they germinate more rapidly and completely than intact fluffs and satisfactory stands could be established using very low seeding rate (Grof, 1957; Brozostowsk, 1961). Any method which could be used easily to extract caryopses will be very useful.

In any crop, storage of seeds till next sowing season is very important and grass seeds are better storers compared to legumes (Parihar and Rai, 1985; Parihar 1986; Vijendradas, 1990). Assessing storability of chaffy seeds, trimmed chaffy seeds and the caryopses will help in proper planning of processing / grading operation before storage or sowing.

Considering the above needs, research efforts were undertaken in *Cenchrus glaucus* cv. CO1 with the following objectives :

i. To ascertain the influence of season and cutting treatments on seed yield and quality
ii. To trace seed development and maturation
iii. To study seed quality as influenced by tillers in a plant

iv. To standardise true seed extraction methods from the fluffs

v. To standardise seed upgradation through specific gravity separator

vi. To develop suitable treatment for breaking dormancy of seeds

vii. To study the effect of pelleting with nutrients on plant establishment and

viii. To evolve suitable seed storage techniques.

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

2.1. Effect of cutting and season on the quality of seed

Forage crops by and large are used as only feeding source to animals and thus harvested at its peak vegetative/reproductive stage, thus affecting the subsequent seed crop.

2.1.1. Plant Height

Defoliation due to grazing often reduced plant height (Winter *et al.*, 1990). Andrade and Thomas (1981) observed reduced plant height in *Andropogan gayanus,* when the crop was cut during the first half of the growing season. Gardner and Wiggans (1960), Taneja *et al.* (1981) and Deo and Rai (1975) also recorded reduced plant height in oats which in turn reduced lodging of the plant. Khara *et al.* (1990) reported more number of primary branches in *Stylosanthus hamata* with the uncut crop.

2.1.2. Tillering

Mishra and Chatterjee (1968) found that repeated cutting stimulated tillering in *Pennisetum polystachyon* and *Andropogan gayanus* but with decreased tiller fertility. Taneja *et al.* (1981) in oats and barley and Deo and Rai (1975) in oats also observed increased tiller production with crop cut once for fodder. But Stur and Humphreys (1987) recorded reduced tiller length with late cutting in *Paspalum plicatulum.*

Macedo *et al.* (1983) observed increased tiller numbers per unit area in *Cenchrus*, when the crop was sown during November and cut in February. The number of total and productive tillers were maximum in the month of May followed by September in *Cenchrus ciliaris* (Jacqueline *et al.*, 1984) Gobius *et al.* (1998) also found increased tiller density with October cuts in *Andropogan gayanus*, but the tiller fertility decreased due to cutting.

2.1.3. Flowering

Gardner and Wiggans (1960) reported that clipping retarded floral development in oats. Stur and Humphreys (1987) also found that late cutting delayed floral initiation in *Paspalum plicatulum*. But in *Andropogan gayanus*, floral stems were not affected by cutting (Terrazas, 1991).

Shasir (1979) reported that cutting early September or last 2 weeks of August recorded higher percentage of clusters containing caryopses in Rhodes grass and buffel grass. Sanchez (1998) also observed increased floral stocks/m^2 in *Andropogan gayanus*, when the crop was cut at 18th July or 2nd August.

2.1.4. Yield components

Deo and Rai (1975) noticed reduced length of panicle and seeds per panicle, whereas Verma *et al.* (1992a) and Prasad and Mukerji (1988) observed reduction in 100 seed weight with cutting treatments in oats. Scheffer *et al.* (1985) also recorded reduction in components of panicles in pearl millet. In *Paspalum* too, late cutting reduced the spikelets raceme^{-1} and seed set (Stur and Humphreys, 1987). Verma *et al.* (1992b) noticed decreased ears shoot^{-1} and weight of seed ear^{-1} with the cutting treatments in deenanath grass. Singh *et al.* (1985) noticed less number of seeds panicle^{-1} combined with reduced 1000 seed weight in oats due to cutting for forage. Decreased 1000 seed weight in *Stylosanthes hamata* (Khara *et al.*, 1990) and alfalfa (Sinko, 1995) with an increase in hard seed content were observed with cutting treatments.

Macedo *et al.* (1983) noticed significant improvement in inflorescence weight and seed set with cutting in February in buffel grass cv. Biloela. Garcia *et al.* (1990) observed more number of empty fascicles in *Cenchrus ciliaris* with late seed harvests. In *Andropogan gayanus*, Gobius *et al.* (1998) recorded nil effect on 1000 seed weight by cutting date but have negative effect on inflorescence size, when final cut was taken between August and October.

Seed weight capsule^{-1} and 1000 seed weight increased with delay in sowing from 1st October to 15th November, whereas the delay in cutting time also increase 1000 seed weight and seed weight capsule^{-1} upto 2nd March in berseem (Sardana and Narwal, 1999). Lucerne cv. CO 1 harvested during 3rd week of July recorded the highest number of racemes and pods with more number of matured seeds (Jacqueline and Srimathi, 1992).

2.1.5. Seed yield

In tropical grasses compensatory effects among the seed yield components were common (Humphreys and Riveros, 1986). But this is not true in all fodder crops.

Taneja *et al.* (1981) observed reduction in seed yield during 1977-78 but no reduction during 1978-79 with cutting treatments in oats and barley. Cutting once at 50 DAS than at 60 DAS (Joshi *et al.*, 1994) or at 80 DAS (Singh *et al.*, 1998) were recommended for higher net returns with both fodder and seed yield in different oats cultivars.

Diego *et al.* (1995) reported that in pearl millet and elephant grass hexaploid hybrids, two cuts per year did not affect the seed yield but three cuts per year reduced it. Sanchez *et al.* (1999) also favoured cutting management for *Brachiaria humidicola* and reported that cutting enabled synchronised flowering and maturity of seeds.

Tarawali *et al.* (1995) reported that shorter cutting intervals of 3-5 weeks enhanced regrowth and seed yield in *Stylosanthes* and *Centrosema.* Similarly,Sinko (1995) observed higher seed yield with alfalfa crop cut at 0.5 m height. Nandanwar *et al.* (1990) in berseem and Hussain *et al.* (1995) in oats observed no effect on seed yield when the crop was cut at 55, 75-85 or 100-115 DAS and 70, 85 and 100 DAS respectively. Drobny and Turayova (1993) also opined that seed yields were not affected when the white clover crop was cut at flower bud formation stage.

Gardner and Wiggans (1960) in oats and Mishra and Chatterjee (1968) in *Pennisetum polystachyon* and *Andropogan gayanus* reported that delayed or repeated clipping decreased the seed yield due to retarded floral development. Prasad and Mukerji (1988) also observed reduced seed yield in fodder crop than pure seed crop in oats. Among the cutting treatments, cutting at 65 or 75 DAS gave significantly higher seed yield.

Garcia *et al.* (1990), Equiarte and Gonzaloz (1993) and Yadav and Rajora (1999) in buffel grass, Verma *et al.* (1992a), Patil *et al.* (1993) and Thakral *et al.* (1993) in oats, Verma *et al.* (1992b) and Prasad (1993) in *Pennisetum pedicellatum,* Marshall and Hides (1999) in perennial rye grass, Martiniello (1999) in clovers. Mukherjee *et al.* (2000) in shaftal and Khara *et al.* (1990) and Dwivedi *et al.* (1998) in *Stylosanthes hamata* recorded higher seed yields, when the crop was not preceded by cutting.

The period of harvest recommended for higher seed yield were summer and early monsoon period for *Cenchrus ciliaris* (Jacqueline *et al.*, 1984); mid December under rainfed conditions for deenanath grass (Parihar and Shankar, 1997) and April-May for *Brachiaria decumbens* (Conde and Garcia, 1983).

The period of cutting for higher outcome were 19th June to 2nd August in north yucatan areas for *Andropogan gayanus* (Ayala, 1994) and November 1st for *Brachiaria humidicola* (Sanchez *et al.*, 1999).

But Sanchez (1998) found nil effect of different cutting dates in *Andropogan.* In contrary, Gobius *et al.* (1998) observed decreased seed yields with all cutting treatments from August to October in *Andropogan gayanus.* Plants cut during 1st week of June came to seed harvest during July recording higher seed yield in lucern cv. CO 1 and April to August was an ideal period for flowering and seed set (Ramaswamy *et al.*, 1981).

Cutting during 20th March for December 1st sown crops and 5th March for late sown on December last or 20th/10th January crops of Egyptian clover was recommended (Taneja *et al.*, 1990). According to Mukherjee *et al.* (2000), early sowing in October than late sowing in November or December gave higher yield in shaftal. Final cutting on 15th March than on 30th March or 15th April was recommended for better seed production in lucerne (Tiwana and Puri, 1997). Barevadia *et al.* (1994) also recorded similar results in lucerne. In Punjab, at Gurdaspur and Ludhiana, last cutting on 10th April and at Bathinda location before 30th March recorded maximum seed yields in berseem (Tiwana *et al.*, 1998).

2.1.6. Quality of seed

Deo and Rai (1975) observed poor germination of oats seeds from cut treatments due to the removal of flower primordia which might have delayed the regrowth and maturity. Thakral *et al.* (1993) and Verma *et al.* (1992a) also reported highest percentage of germination, seedling length and dry matter production of oat seedlings from uncut treatments.

2.2. Effect of harvest date on seed quality

Indeterminate growth (non synchronized) habit, uneven maturity, blank seed, seed dormancy and seed shattering are some of the limiting factors causing poor seed yield of forage crops. Identification of harvest date is one of the basic approaches for getting maximum seed recovery.

2.2.1. Seed moisture

Hyde *et al.* (1959) recorded high moisture content for the first 10 days after pollination which gradually decreased and reduced to about 40 per cent and equilibrated with atmospheric humidity at maturity in rye grass. Narayanaswamy and Javaregowda (1986) also found high moisture content of the finger millet seed at milky stage which gradually declined as days advanced. Similarly, the decreasing trend of moisture content of maturing seed was noticed by Narayanasamy (1994) in deenanath grass and Krishnarajan (1996) in guinea grass.

2.2.2. Seed weight

Stoddart (1968) observed four stages of seed development in grasses. The first 7-14 days after fertilization where seed weight characterized by rapid increase in seed size and fresh weight followed by second stage, where the rate of increase diminished markedly, terminating with the attainment of maximum fresh weight. After that stable seed weight was attained. Similar results were reported by Narayanasamy (1994) in deenanath grass, Krishnarajan (1996) in guinea grass, Zade *et al.* (1993) in rice bean and Angamuthu (1991) in small millets.

Panicle length was not significantly affected by different stages of harvest after panicle emergence in grasses (Krishnan, 1993; Narayanasamy, 1994; Krishnarajan, 1996).

Anslow (1964) stated that the final weight attained by individual seed depended upon its position within the earhead and age of the tiller. Within each ear, the apical spikelets possessed slightly lighter seed than basal and intermediate ones. Narayanasamy (1994) also observed the same pattern with the position of seeds in deenanath.

2.2.3. Physiological maturity

Physiological maturity occurs at different dates for different species and cultivars at different climatic zones. Physiological maturity occurs at, 21-28 days from the commencement of flowering in *Cenchrus* hybrid CIH-2 (Gonzalez and Mendoza, 1996), 12 days after full anthesis in *Cenchrus ciliaris* (Singh and Yadav, 1986), 12-16 DAA for *Cenchrus ciliaris* cv. Cazri 358 (Singh and Yadav, 1988), 12 – 16 DAA in *Cenchrus ciliaris* and *C. setigerus* (Yadav and Rajora, 1999), 35 days after the onset of vigorous flowering in *Brachiaria brizantha* (Matias, 1994), 25 – 35 DAA for *B. humidicola* (Sanchez *et al.*, 1999), fourth to sixth week after the beginning of flowering (Oliveira and Masterocola, 1980) and 32 – 38 days after exertion of inflorescence (Conde and Garcia, 1983) in *B. decumbens,* 21 – 28 days after peak flowering in *Andropogan gayanus* (Gonzalez and Mendoza, 1992), fifth week in cv. Pusa 3 and sixth week in TNDN 1 after 50 per cent flowering in deenanath grass (Narayanasamy, 1994), fifth week after 50 per cent flowering in Co.1 guinea grass (Krishnarajan, 1996), 15-20 days after panicle emergence in *Panicum maximum* (Machado *et al.*, 1984), 22 – 25 DAA in *P. coloratum* (Young, 1993), 12 days after dough stage (35 DAA) in forage sorghum (Narwal and Sharma, 1998), 22 DAA in rice bean (Zade *et al.*, 1993), 21 days after anthesis in *Stylosanthes hamata* (Srikanth, 1994), 14 days after start of pod maturation (20 per cent dry seeds) in *Centrosema acutifolium* cv. CIAT 5112 (Gonzalez, 1998), 14 DAA in fodder cowpea cv. IGFRI and 17 DAA in cv. EC4216 (Rakesh *et al.*, 1999) and 30 days after fertilization in lucern cv. CO 1 (Ramaswamy *et al.*, 1981).

2.3. Effect of dormancy breaking methods

In most of the grass species, seeds possess post harvest dormancy and needs some period of storage for the release of dormancy (Whiteman and Mendra, 1982; Harty *et al.*, 1983; Parihar *et al.*, 1999a).

2.3.1. Dehulling/removal of glumes

Deglumed seeds recorded more germination than spikelets as such in *Cenchrus* sp. (Parihar *et al.*, 1984a and 1984b; Vijendradas, 1990; Venter and Rethman, 1992; Ernst *et al.*, 1991); *Panicum maximum* (Okada, 1985; Smith, 1971; Ernst *et al.*, 1991; Hongru *et al.*, 1995); sandbur seeds (*Cenchrus echinatus)* (Martins *et al.*, 1997); *Brachiaria brizantha* (Montorio *et al.*, 1997); *Brachiaria decumbens* (Whiteman and Mendra, 1982); deenanath grass (Parihar and Shankar, 1997) and in atra paspalum (Kalambacher *et al.*, 1999) indicating that glumes also contained dormancy causing factors.

2.3.2. Acid/Mechanical scarification

In fall panicum seeds, mechanical and acid scarification improved germination (Brecke and Duke, 1980), whereas mechanical scarification improved germination effectively with added advantage of speed and simplicity in *Panicum maximum* (Basra *et al.*, 1990) and in *Brachiaria decumbens* (Castro *et al.*, 1996).

Seeds scarified with sulphuric acid recorded high germination in *Panicum maximum* (Smith, 1971; Hongru *et al.*, 1995; Usberti and Valio, 1997), *Brachiaria brizantha* (Montorio *et al.*, 1997; Martins and Lago, 1996; Castro *et al.*, 1994), *Brachiaria decumbens* (Lima and Cardoso, 1996), *Panicum antidotale* (Parihar *et al.*, 1999a), *Paspalum dilatum* (Tischler and Burson, 1999), Indian grass (James and Conard, 1973), klein grass (Tischler and Young, 1983), needle grass (*Stripa viridula*) (Rubida and Gultormson, 1988) and in switch grass (Tischler *et al.*, 1994).

But Toledo *et al.* (1995) and Maiti *et al.* (1981) reported that scarification with H_2SO_4 was not effective in eliminating the dormancy of *Panicum maximum* and *Pennesetum pedicellatum* seeds. Usberti *et al.* (2000) also opined that chemical scarification alone was not effective in releasing the dormancy of *Panicum maximum* and that it was successful only in early and very early flowering types.

2.3.3. Soaking in KNO_3 solution

Soaking seeds in KNO_3 solution at different concentrations effectively releases the seed dormancy of *Cenchrus ciliaris* (Bhubathi *et al.*, 1983), *Brachiaria* sp. (Faria *et al.*, 1996), *Brachiaria humidicola* (Ruiz *et al.*, 1996), *B. decumbens* (Herrera, 1994b), guinea grass (Smith, 1979; Ramaswamy *et al.*, 1981; Gonzalez and Torriente, 1984; Toledo *et al.*, 1994; Previero *et al.*, 1996), blue panic grass (Parihar *et al.*, 1999a), needle grass (Young *et al.*, 1990), deenanath grass (Narayanasamy, 1994), sand bur (*Cenchrus echinatus*) (Martins *et al.*, 1997) and of *Andropogan gayanus* (Eira, 1983).

2.3.4. Soaking in Gibberellic acid solution

Gibberellic acid is also effective for the germination improvement of seeds of *Panicum antitotale* (Shahi and Sen, 1991; Shahi, 1992; Parihar *et al.*, 1999a), *Cenchrus ciliaris* (Shahi and Sen, 1991), *Panicum maximum* (Hongru *et al.*, 1995; Usberti and Valio, 1997), *Panicum virgatum* (Zarnstorff *et al.*, 1994), *Brachiaria brizantha* (Vieira *et al.*, 1998 and 1999), needle grass (Young *et al.*, 1990) and deenanath grass (Narayanasamy, 1994).

2.3.5. Acid scarification followed by soaking in KNO_3/GA

Seeds scarified with H_2SO_4 , dried and again soaked in KNO_3 solution with alternating temperature released dormancy in *Panicum maximum* (Smith, 1971). Basra *et al.* (1990) and Previero *et al.* (1996) also recorded similar results in *P. maximum* seeds.

Brachiaria brizantha (Garcia and Cicero, 1992), *B. humidicola* (Oliveira and Masterocola, 1983) and *B. decumbens* (Herrera, 1994b) seeds also showed improvement in germination with acid scarification followed by drying and KNO_3 soaking.

Hongru *et al.* (1995) and Singh *et al.* (1995) observed more than 75 per cent germination in *Panicum maximum*, when seeds were acid scarified and soaked in gibberellic acid solution. Acid scarification for 6-12 min and then moistening of the substrate with 0.05 per cent GA improved the germination of needle grass to 86 per cent (Rubida and Gultormson, 1988).

Krishnarajan (1996) recommended acid scarification followed by KNO_3 + GA_3 soaking for CO 1 guinea grass.

2.3.6. Heat treatment

Butler (1985) recommended predrying at 40°C for 10 days to break dormancy of *Cenchrus ciliaris* seeds and Ernst (1991) recommended dry heat of 100°C for 2 min to *Cenchrus ciliaris* seeds. Lago and Martins (1998) recorded improved germination with dry heating at 40°C for 7 days, whereas, Silva (1998) recommended 85°C to reduce the dormancy of *Brachiaria brizantha*. *Paspalum atratum* seeds needed 40°C for 72 - 240 h (Hare *et al.*, 1999) for dormancy release.

Taylerson (1980) observed dark imbibition at 35°C for one week period to be the most effective in releasing dormancy of *Panicum dichotimiflorum* seeds. Alternate temperature of 30°/15°C to *Panicum maximum* (Smith, 1971), 20°/30°C to *Cenchrus ciliaris* (Butler, 1985) and 30°/10°C to Brazilian oat types (Delatorre and Souza, 1998) were recommended for the release of seed dormancy.

2.3.7. Other treatments

Montorio *et al.* (1997) recorded more germination with soaking in concentrated sulphuric acid for 15 min followed by distilled water soaking for 24 h in *Brichiaria brizantha* seeds. Soaking in tap water for 2-4 days followed by drying improved germination of buffalo grass (*Buchloe dactyloides*) (Wenger, 1941). Washing with running tap water for 2.5 h (Venter and Rethman, 1992), irradiation at 15 KR (Khan, 1988) and soaking in 30 ppm of either 1-m or 1'-P Nitrophenyl indol-2-Carboxylic acid in the presence of light (Chaudry *et al.*, 1999) improved seed germination of *Cenchrus ciliaris*.

West (1992) accelerately aged the bahia grass seeds at 41°C with 100% RH to increase the germination to 95 per cent. Osmoconditioning with or without 0.2 per cent KNO_3/1 mM GA_3 or matriconditioning with Microcel-E with KNO_3/GA_3 increased the germination of *Panicum virgatum* (Madakadze *et al.*, 2000). The mean germination time was decreased for both scarified and intact seeds of *Panicum maximum* by osmoconditioning the seeds with PEG 6000 solution for 7 days at 15 or 25°C (Usberti and Valio, 1997).

Immersion of *Paspalum notatum* seeds in H_2SO_4 for 4 min followed by soaking in hydrogen cynamide (4 per cent) or KNO_3 (0.8 per cent) increased the germination to 59 and 48 per cent respectively (Herrera, 1994a).

2.4. Effect of seed size

Forage grasses are having 1-5 seeds per spikelet and hence variation occurs in seed size, which reflects on seed germination and seedling establishment.

Lahiri and Kharabanda (1961) recorded dimorphic seeds in forage grasses and observed increased seedling length with large seeds of *Lasirus, Cenchrus ciliaris* and *Cenchrus setigerus*. Arunkumar and Joshi (1970) also noticed dimorphic seeds in *Cenchrus biflorus* and *C. prieuriti*, but seed size effect was reverse in *C. prieuriti*.

Kathju *et al.* (1978) and Lahiri *et al.* (1982) observed higher leaf stem ratio, reducing sugar, starch and total carbohydrates in the plants from larger seeds of *Cenchrus ciliaris* only in the first year of establishment. The effect of size was nil during the 2nd year. Smart and Morer (1999) also reported that by 8-10 weeks after emergence the growth and development of switch grass seeds were similar.

Ernst and Tolsma (1992) also noticed enhancing leaf area and root length in seedlings derived from large caryopses of *Cenchrus ciliaris, Panicum maximum* and *Urochola mosambicensis*. Similar results were reported in wheat, spring oats and spring barley by Guberac *et al.* (1999).

2.5. Effect of seed pelleting

Grass seeds are lighter in weight and coating/pelleting improves seed ballistics and facilitates aerial seeding or uniform sowing through seed drills.

2.5.1. Germination

Increased germination on barren lands was noticed in seeds of *Poa pratensis*, coated with cytokinin (Greppsson, 1999) and bermuda grass pelleted with kaolin (Albert and Miller, 1987). Kim *et al.* (2000a) found 10 per cent peat moss as the best coating material for tall fescue seeds. Kim *et al.* (2000b) recorded low germination energy with coated seeds of tall fescue and orchard grass. Craiu (1994) observed nil differences between the pelleted and non-pelleted lucerne seeds. Younger and Gilmore (1979) and Ros *et al.* (2000) recorded decreased seedling emergence with phosphorus coated seeds of *Cenchrus* and rice respectively.

2.5.2. Stand establishment

Greppsson (1999) reported good establishment of *Poa pratense* with cytokinin and diatomaceous earth coating than water retaining polymer coating of seeds. Kim *et al.* (2000b) suggested methyl cellulose as the best adhesive and Tri calcium phosphate as a phosphorus source for seed coating. Hosmani *et al.* (1998) recommended pelleting the seeds of *Stylosanthes* with biogas slurry for better plant establishment and rock phosphate pelleting for good fodder yield. Ros *et al.* (2000) observed higher root and shoot dry weights at 40 DAS with single super phosphate and rock phosphate coating for rice seeds. Better plant establishment was noticed in *Cenchrus* (Jaisingh, 1996) and bermuda grass (Albert and Miller, 1987) with pelleted seeds. Pelleting with super phosphate increased the dry matter yield in *Cenchrus* (Younger and Gilmore, 1979).

Angamuthu (1991) registered higher values of field emergence, plant height, length of earheads and seed yield in minor millets with polymer + arappu leaf powder pelleting. Horikawa and Ohtsuka (1996) observed increased nodulation in *Medicago sativa* when the seeds were coated with *Rhizobium melilotii* than the vaccum processed or adhesive treated seeds. Craiu (1994) recorded increased seed yield in lucerne, when pelleted seeds were sown. Wang and Hong (1995) noticed higher crude protein and lower crude fibre levels of plants from seeds coated (dry dressed) with H_2MoO_4, 48 h before sowing.

2.5.3. Storage

Pelleted grass seeds stored well for more than two months without reduction in germination (Vartha and Clifford, 1973). Albert and Miller (1987) reported that pelleted seed maintained the seed and the Rhizobium viability upto six months. Horikawa and Ohtsuka (1996) recorded decreased viability of *Rhizobium melilotii* only after six months of storage in lucerne seeds.

2.6. Seed storage

2.6.1. Container

Storage containers show nil variation on seed viability under short term storage of grass seeds since they need an after ripening period of 2-6 months for dormancy release. Conde and Garcia (1995) observed no significant variation between different containers in the storage of andropogan seeds. For long term storage of seeds, sealed containers in *Panicum maximum* (Peel and Prondroff, 1978), air tight aluminium containers in *Cenchrus* and *Andropogan* (Rivero *et al.*, 2000) and poly bag containers in *Brichiaria brizantha* (Previero *et al.*, 1998) and *Cenchrus ciliaris* (Parihar *et al.*, 1984a) were recommended.

2.6.2. Storage conditions

Caryopses loose their viability faster than spikelets under storage. Seeds stored at low temperature reach peak germination slower than at ambient storage conditions.

The highest values of vigour and viability of seeds at natural ageing under ambient and low temperature (freezing or 5-10°C) regimes were recorded at 3rd and 16-20 months for *Brachiaria decumbens* cv. Basilisk (Gonzalez *et al.*, 1993); 2nd and 12 months in cv. 621 (Gonzalez and Torriente, 1985) and 8 and 20 months of storage in cv. CIAT 621 (Gonzalez and Mendoza, 1993) of *Andropogan gayanus*; 6 and 12 months for *Brachiaria decumbens* (Gonzalez *et al.*, 1994) and 6 and 12 months for *Panicum maximum* cv. CIH 3 (Gonzalez and Mendoza, 1994) respectively. *Panicum maximum* (Peel and Prondroff, 1970) and *Paspalam* (Kalambacher *et al.*, 1999) seeds could be stored well at ambient conditions. Oliveira and Masterocola (1984) recommended storage at 15° and 30 per cent RH for *Panicum maximum*. *Andropogan gayanus* needs 13°C (Cordeso and Oliveros, 1983) for safer storage.

2.6.3. Dormancy release

Peak germination occurs after 6 months in klein grass (Tischler and Young, 1983), 2 months in *Panicum maximum* cv. Likoni (Gonzalez and Torriente, 1983), 21 weeks in *P. maximum* (Paramatma and Surendran, 1990), 12 months (Gonzalez and Mendoza, 1993) and 6 months (Garcia *et al.*, 1998) in *Andropogan,* 6 months in *Brachiaria brizantha* (Garcia *et al.*, 1998; Matias, 1998) and *B. decumbens* (Gonzalez *et al.*, 1993 and 1994), 90-100 days in *B. humidicola* (Sanchez *et al.*, 1999), 34 weeks in *Pennesetum pedicellatum* (Paramatma and Surendran, 1990), 26 weeks in *Panicum virgatum* (Zang and Maun, 1989), 10 months in *Cenchrus glaucus* (Vijendradas, 1990), 12 months in *C. ciliaris* (Jacqueline and Ramaswamy, 1986 and Parihar *et al.*, 1984a) and 18 month in *C. setigerus* (Parihar, 1986).

2.6.4. Storage of scarified seeds

Vierira-neto and Aragao (1984) observed no loss of viability in seeds of buffel grass treated with 24 M H_2SO_4, but scarified seeds of *Brichiaria brizantha* showed greater losses in viability than untreated ones in long term storage (Previero *et al.*, 1998).

Herrera (1994b) recorded better germination with KNO_3 treated seeds than H_2SO_4 treated seeds in *B. decumbens*. In *Oryzopsis miliacea* seeds, the beneficial effect of scarification + priming (24 h soaking in PEG at –1.0 MPA + GA at 10^{-3}) were maintained over a period of 6 months (Mauromicale and Irena, 1994).

MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

3.1. Materials

Seeds of *Cenchrus glaucus* (cv. CO 1) obtained from the Department of Forage Crops, Tamil Nadu Agricultural University, Coimbatore formed the base material for the studies. The field experiments were conducted at the New area of the Millet Breeding Station, Centre for Plant Breeding and Genetics, Tamil Nadu Agricultural University, Coimbatore.

The morphological features of cv. CO 1 are presented in Annexure 1.

3.2. Methods

3.2.1. Influence of dates of sowing and cutting treatments on yield and quality of seeds

A field experiment was laid out with four dates of sowing and three cutting treatments to find out the influence of season and cutting for fodder on plant growth, seed yield and quality in *Cenchrus glaucus* cv. CO 1. The details of the experiment were as follows:

Treatments

Dates of sowing

S_1 - 30th January 2000

S_2 - 5th June 2000

S_3 - 28th July 2000

S_4 - 6th November 2000

Cutting treatments

C_1 - Seed - Seed	:	Crop was left for maturation as such without cutting for forage
C_2 - Seed - one cut - Seed	:	Crop was given first cut at 50 per cent flowering stage for forage and left for seed set
C_3 - Seed - two cuts - Seed	:	Crop was given two cuts at 50 per cent flowering stage for forage and left for seed set

Design	:	FRBD
Replication	:	Three
Plot size	:	4 x 3m
Spacing	:	60 x 30 cm

Crop was raised from seeds and the cuttings were given at 50 per cent flowering stage. The crop was cut at a height of 15 cm from the ground level. The recommended cultural and plant protection measures for *Cenchrus* seed production were followed. The matured seeds were collected at weekly intervals till the crop was exhausted. The following observations were made in the seed crop :

3.2.1.1. Plant height

Before seed collection, the plant height was measured from ground level to the tip of the inflorescence of the main tiller in five randomly selected plants plot^{-1} and the mean was expressed in cm.

3.2.1.2. Number of total tillers

The total number of primary tillers plant^{-1}, leaving the secondary branches in the randomly selected five plants plot^{-1} were counted and the mean was reported.

3.2.1.3. Number of fertile tillers

The total number of tillers having inflorescence plant^{-1} in the randomly selected five plants plot^{-1} were counted and the mean fertile tillers plant^{-1} was reported.

3.2.1.4. Days to first flowering

The number of days taken from the date of sowing to initiation of flowering was recorded in days.

3.2.1.5. Days to 50 per cent flowering

The days taken from the date of sowing to 50 per cent of the plant population plot^{-1} to attain flowering stage was expressed in days.

Plate 2. Experimental field view of *C.glaucus* cv. CO 1

3.2.1.6. Spike length

Five spikes were randomly selected and the length was measured from base to the tip of the spike and the mean was expressed in cm.

3.2.1.7. Spike weight

Five spikes used for length measurement were weighed accurately and the mean value was expressed in mg.

3.2.1.8. Number of fluffs spike^{-1}

Ten spikes each were taken at random and the number of fluffs spike^{-1} was counted and the mean was reported.

3.2.1.9. Percentage ill filled fluffs

Ten spikes each were taken at random and the chaffy fluffs spike^{-1} were counted and expressed as percentage of ill filled fluffs.

3.2.1.10. Fluff yield plot^{-1}

Mature spikes were collected at weekly intervals plotwise and cumulative yield of all collections was reported as fluff yield plot^{-1}.

3.2.1.11. Pure fluff yield plot^{-1} and ha^{-1}

Fluffs from each plot were graded and the filled fluffs were weighed and the fluff yield plot^{-1} was computed. Fluff yield ha^{-1} was also computed.

3.2.1.12. Hundred fluff weight

Eight replications of 100 fluffs each were drawn treatmentwise, weighed in a sensitive electronic balance and expressed in mg.

3.2.1.13. Germination

The true seeds/caryopses extracted manually were used to conduct the germination test. Germination test was conducted in between paper medium. The test conditions were 25/30°C at 90 ± 5% RH. Germination period of 14 days was adopted (ISTA, 1990). The normal seedlings counted were expressed as percentage germination.

3.2.1.14. Root length

The length of the root was measured from the collar region to the tip of the primary root in ten normal seedlings taken at random from the germination test and the mean value was expressed in cm.

3.2.1.15. Shoot length

Shoot length was measured from the collar region to the tip of the primary leaf in the same ten seedlings used for root length measurement and the mean value was expressed in cm.

3.2.1.16. Vigour index

The vigour index was computed by multiplying percentage germination and total seedling length (cm) and expressed as a whole number (Abdul-Baki and Anderson, 1973).

3.2.2. Seed development and maturation

A field trial was laid out adopting randomised block design with three replications during November to March, 2001. The crop was raised from seeds and large number of spikes were tagged at the same stage of anthesis. Sufficient number of spikes were harvested at three day interval from the start of anthesis to 21 days after anthesis (DAA) for studying the development and maturation of seeds. The stages of collection of spikes were represented as D_3, D_6, D_9, D_{12}, D_{15}, D_{18} and D_{21} representing 3, 6, 9, 12, 15, 18 and 21 DAA respectively. The spikes were separated into proximal (P_1), middle (P_2) and distal (P_3) portions and the following observations were made :

3.2.2.2. Spike length

Five spikes were randomly selected from each harvest and the length was measured from the base to tip and the mean was expressed in cm.

3.2.2.3. Fresh weight of spike

Spikes used for length measurements were separated into proximal, middle and distal one third portions and each portion weighed separately and the mean was expressed in mg.

3.2.2.4. Dry weight of spike

The spikes after recording the fresh weight were dried in a hot air oven maintained at 85 ± 2°C for 16 h. After cooling for 30 min. in a desiccator, the dry weight was recorded and the mean value was expressed in mg.

3.2.2.5. Fresh weight of fluffs

Four replications of 100 fluffs from each portion was counted. The fresh weight was weighed and the mean was expressed in mg.

3.2.2.6. Dry weight of fluffs

The fluffs used for fresh weight determination were dried as detailed in 3.2.2.4. The dry weight was recorded separately and the mean was expressed in mg.

3.2.2.7. Number of fluffs spike^{-1}

Ten spikes each were taken at random at chosen stages and the number of fluffs spike^{-1} was recorded.

3.2.2.8. Number of seeds fluff^{-1}

Ten fluffs were taken at random and the number of seeds present in each fluff was counted and the mean value was recorded.

3.2.2.9. Number of filled and ill filled seeds fluff^{-1}

Ten fluffs were taken at random and the number of filled and ill filled true seeds in each fluff were counted and the mean number was recorded.

3.2.2.10. Hundred seed weight

Eight replications of 100 true seeds each were counted and weighed accurately and expressed in mg.

3.2.2.11. Moisture content of spike and fluff

Moisture estimation was carried out by using the low temperature constant method. The entire spike was used for the moisture determination of spikes and fluff as such for fluff moisture content. After recording the fresh weight, the spike/fluff was dried at 105 ± 2°C in a hot air oven for 16 h. After cooling for 30 min. in a desiccator the dry weight of the spikes/fluffs was recorded. The moisture content was calculated using the following formula:

$$\text{Moisture content (\%)} = \frac{M_2 - M_3}{M_2 - M_1} \times 100$$

Where,

M_1 = weight of the container alone

M_2 = weight of container + sample before drying

M_3 = weight of container + sample after drying

3.2.2.12. Germination

Germination test was conducted in top of the paper medium with true seeds extracted manually from each stage. At the end of 14 days of germination period, the number of normal seedlings was counted and expressed in percentage.

3.2.3. Seed quality as influenced by tillers

Cenchrus glaucus cv. CO 1 crop was raised from seeds in pots adopting randomised block design with four replications. The tillers were marked according to their sequence of emergence from first to seventh tiller (T_1 to T_7). T_8 denotes the second emerged spike from the first tiller. They were harvested when the fluffs attained maturity (when the fluff turned straw color). The following seed quality parameters were studied as detailed in 3.2.1.

3.2.3.1. Spike length

3.2.3.2. Spike weight

3.2.3.3. Number of fluffs spike^{-1}

3.2.3.4. Number of seeds fluff^{-1}

3.2.3.5. Germination

To assess the germination of seeds tillerwise, the true seeds were extracted and sieved with BSS 24 x 24 wiremesh sieve and both the retained and passed seeds were subjected to the germination test on top of the paper media.

3.2.3.6. Hundred fluff weight

3.2.3.6. Assessing the dormancy period of fluffs

The fresh fluffs from all tillers exhibited dormancy, when sown as such and thus the fluffs were cleaned, dried and stored in paper bags tillerwise to assess the dormancy period of the fluffs. The stored fluffs were subjected to germination test at three months interval upto nine months (designated as P_0, P_1, P_2, P_3).

3.2.4. Standardisation of temperature and media requirement for germination

To standardise the optimum temperature and suitable medium for germination of the fluffs, the following test conditions were tried :

Temperature	:	20°C, 25°C and 30°C as constant and 20-25°C, 20-30°C and 25-30°C as alternate temperature (Higher temperature for 8h and lower temperature for 16 h respectively) designated as T_1 to T_6 respectively.
Media	:	Sand (S), Roll towel (RT) and Top of Paper (TP) designated as M_1, M_2 and M_3 respectively.
Design	:	CRD
Replication	:	Four

Fluffs were germinated in the above media maintained at different temperature ranges. The following observations were recorded :

3.2.4.1. Number of days for germination initiation

The number of days required for radicle emergence was taken as the days required for initiation of germination.

3.2.4.2. Rate of germination

During the germination test, the emergence of seedling was counted from initiation upto completion. From the mean percentage germination recorded on each counting date. rate of germination was calculated using the formula suggested by Maguire (1962).

$$\text{Rate of germination} = \frac{x_1}{y_1} + \frac{x_2 - x_1}{y_2} + \ldots + \frac{x_n - x_{(n-1)}}{y_n}$$

Where,

x_n - number of seeds germinated at n^{th} day

y_n - number of days from sowing to n^{th} day

3.2.4.3. Germination

After the completion of 14 days of germination period, the number of normal seedlings were counted and the percentage of germination was calculated.

3.2.4.4. Root length as detailed in 3.2.1.14

3.2.4.5. Shoot length as detailed in 3.2.1.15

3.2.4.6. Vigour index as detailed in 3.2.1.16

3.2.5. Seed extraction techniques

The true seeds (caryopses) were separated by adopting the following techniques :

a. Manual defluffing

Fluffs were rubbed in between palms and the seeds were separated from lemma and palea and collected following careful cleaning.

b. Mechanical defluffing

The fluffs were defluffed using a mechanical defuzzer intended to separate the sugarcane seed from the fluff. Here the fluffs were first mixed with sand (1:3 ratio) and fed in to the defuzzer for 10 min. The seed fluff mixture was then sieved through wiremesh sieve. The sand particles passed through the sieve and the seeds retained on the sieve were collected.

c. Using sulphuric acid

The fluffs were treated with commercial grade sulphuric acid @ 12 ml gm^{-25} of fluff for different durations of seven to 20 minutes. The fluffs were taken in a dry plastic bucket to which measured quantity of acid was added uniformly and stirred with a bamboo stick for the desired duration and washed immediately with water. After four washings, the seeds were carefully decanted with the help of closely knitted wire mesh sieve. Owing to the small size of seeds, considerable difficulty was encountered in removing good seeds without being lost. After thorough washing, the seeds were initially dried under fan and subsequently sundried to bring the seed moisture content to around 10 per cent. Then the seeds were rubbed in between palms and then cleaned by blowing the seeds in the air blower at 0.55 mg pressure for 15 min.

Treatments

T_1	-	Manual defluffing
T_2	-	Mechanical defluffing for 10 min
T_3	-	H_2SO_4 scarification for 7 min
T_4	-	H_2SO_4 scarification for 10 min

T_5 - H_2SO_4 scarification for 13 min

T_6 - H_2SO_4 scarification for 16 min

T_7 - H_2SO_4 scarification for 20 min

Design : CRD

Replications : Three

After the seed extraction by different methods, the seeds from each method were evaluated for the following quality characters :

3.2.5.1. Seed recovery

Seeds obtained after thorough cleaning were weighed and the recovery percentage was calculated.

3.2.5.2. Injured seeds

Four replications of 100 seeds each were observed individually under microscope for the injury (scorching) and the damaged seeds were counted and expressed as percentage of damage.

3.2.5.3. Seed viability

The pre-conditioned (3 h water soaking) seeds were immersed in 0.5 per cent tetrazolium chloride solution overnight in dark under lab conditions. Subsequently the seeds were washed well with water and the staining pattern was studied using the stereo microscope and the viable seeds were counted and expressed as viability per cent.

3.2.5.4. Germination as detailed in 3.2.1.13

3.2.5.5. Root length as detailed in 3.2.1.14

3.2.5.6. Shoot length as detailed in 3.2.1.15

3.2.5.7. Vigour index as detailed in 3.2.1.16

3.2.6. Fixing optimum deck slope and air flow rate for specific gravity grading

The fluffs were treated with commercial sulphuric acid @ 300 ml kg^{-1} of fluffs and stirred for 4 min and washed thoroughly with tap water for 4-5 times. Then the seeds were dried under shade and sun to bring the moisture content of seeds to around 10 per cent. Then seeds were graded with specific gravity separator to eliminate chaffy/ illfilled seeds. In the specific gravity separator, to fix the optimum slope of the deck and the air flow rate several combinations were tried. Deck slope was adjusted by using the horizontal and vertical scales and the deck oscillation was adjusted at 500-520 rpm.

Treatments

Horizontal scale (H)	:	0 and 1
Vertical scale (V)	:	0, 0.5, 1 and 1.5
Air flow rate (A)	:	3 and 4
Design	:	CRD
Replication	:	Four

The oscillating movement of the table 'walks' the heavy-seeds in contact with the deck uphill, while the air floats the light seeds down hill. The seeds travelling to the edge of the table ranged from light at the lower end to heavy at the upper end and discharged into 5 density fractions designated as G_1, G_2, G_3, G_4 and G_5 where 'G_1' was the heaviest seed and 'G_5', the lightest seed fraction.

After grading, the seeds were evaluated for the following observation :

3.2.6.1. Seed recovery

Seeds discharged as G_1-G_5 in different outlets were weighed separately and the percentage recovery was calculated.

3.2.6.2. Hundred fluff weight as detailed in 3.2.1.12

3.2.6.3. Percentage ill filled seed

Four replications of 50 fluffs were dissected out and ill filled fluffs were counted and the mean was expressed in percentage.

3.2.6.4. Germination

The fluffs were placed for germination as detailed in 3.2.1.13. Fluff was considered as a single seed unit for counting as normal seedling.

3.2.6.5. Root length as detailed in 3.2.1.14

3.2.6.6. Shoot length as detailed in 3.2.1.15

3.2.6.7. Vigour index as detailed in 3.2.1.16

3.2.7. Dormancy breaking methods

3.2.7.1. Scarified fluffs

The fresh fluffs were scarified with commercial grade sulphuric acid for 4 min. as detailed earlier and graded with specific gravity separator. The best fractions G_1 and G_2 were taken for conducting this experiment. Acid scarified fluffs were taken as control and the following treatments were imposed for a soaking period of 16 h :

Treatments

T_0	-	Scarified fluffs
T_1	-	Water soaking
T_2	-	0.5% KNO_3
T_3	-	1% KNO_3
T_4	-	2% KNO_3
T_5	-	25 ppm $CuSO_4$
T_6	-	50 ppm $CuSO_4$

T_7	-	25 ppm ascorbic acid
T_8	-	50 ppm ascorbic acid
T_9	-	100 ppm GA_3
T_{10}	-	200 ppm GA_3
T_{11}	-	500 ppm GA_3

Design : CRD

Replications : Four

The following fluff quality parameters were recorded as detailed in 3.2.6.

3.2.7.1.1. Germination

3.2.7.1.2. Root length

3.2.7.1.3. Shoot length

3.2.7.1.4. Vigour index

3.2.7.2. Bioassay test

Glumes of 5 g from freshly harvested spikelets were removed and ground to powder and then soaked in 50 ml of distilled water to form suspension. The suspension was stirred well and kept overnight. Then it was filtered and the filtrate was used as a stock solution (standard inhibitor) to moisten the top of paper medium for the bioassay test with true seeds of *Cenchrus glaucus*.

The standard inhibitor was diluted in the proportions of 1:0, 1:1, 1:2 and 1:5 with distilled water and the medium was moistened with this solution during germination. The following observations were recorded as detailed in 3.2.6.

3.2.7.2.1 Germination

3.2.7.2.2. Root length

3.2.7.2.3. Shoot length

3.2.7.2.4. Vigour index

3.2.7.3. True seeds

True seeds extracted as described earlier were subjected to the following dormancy breaking treatments (as that of fluffs).

Treatments

T_0	-	Control
T_1	-	Water soaking
T_2	-	1% KNO_3
T_3	-	2% KNO_3
T_4	-	25 ppm $CuSO_4$
T_5	-	50 ppm $CuSO_4$
T_6	-	25 ppm ascorbic acid
T_7	-	50 ppm ascorbic acid
T_8	-	100 ppm GA_3
T_9	-	200 ppm GA_3
T_{10}	-	500 ppm GA_3

Design : CRD

Replications : Four

The following seed quality parameters were assessed as detailed in 3.2.1.

3.2.7.3.1. Germination

3.2.7.3.2. Root length

3.2.7.3.3. Shoot length

3.2.7.3.4. Vigour index

3.2.8. Seed pelleting

The fluffs were scarified with sulphuric acid for 4 min. and dried to a moisture content of around 10 per cent and then graded by the specific gravity separator. Only the heaviest seed fractions were taken and pelleted using the following materials :

Nutrients : DAP @ 60 g kg^{-1} seeds

$FeSo_4$, $ZnSO_4$, $CuSO_4$, $MnSO_4$ and Borax @ 10 g kg^{-1} seeds

Adhesives : 10 per cent maida gruel

Filler : Arappu leaf (*Albizia amara*) powder @ 500 g kg^{-1} seeds

Initially thin coating of filler was given followed by the nutrients and again the filler. Adhesive was added as and when necessary. The seeds were given a centrifugal rotation in a locally devised hand operated pelletizer. This facilitated an even coating of the filler material on the seeds.

3.2.8.1. Effect of pelleting

Treatments

T_0 - Control (without pelleting)

T_1 - Arappu leaf powder (filler alone)

T_2 - DAP

T_3 - DAP + $FeSO_4$

T_4 - DAP + $ZnSO_4$

T_5 - $FeSO_4$

T_6 - $ZnSO_4$

T_7 - $CuSO_4$

T_8 - $MnSO_4$

T_9 - Borax

Design : CRD

Replications : Four

The pelleted seeds were evaluated initially and three months after storage designated as P_0 and P_3 for the following parameters as detailed in 3.2.1.

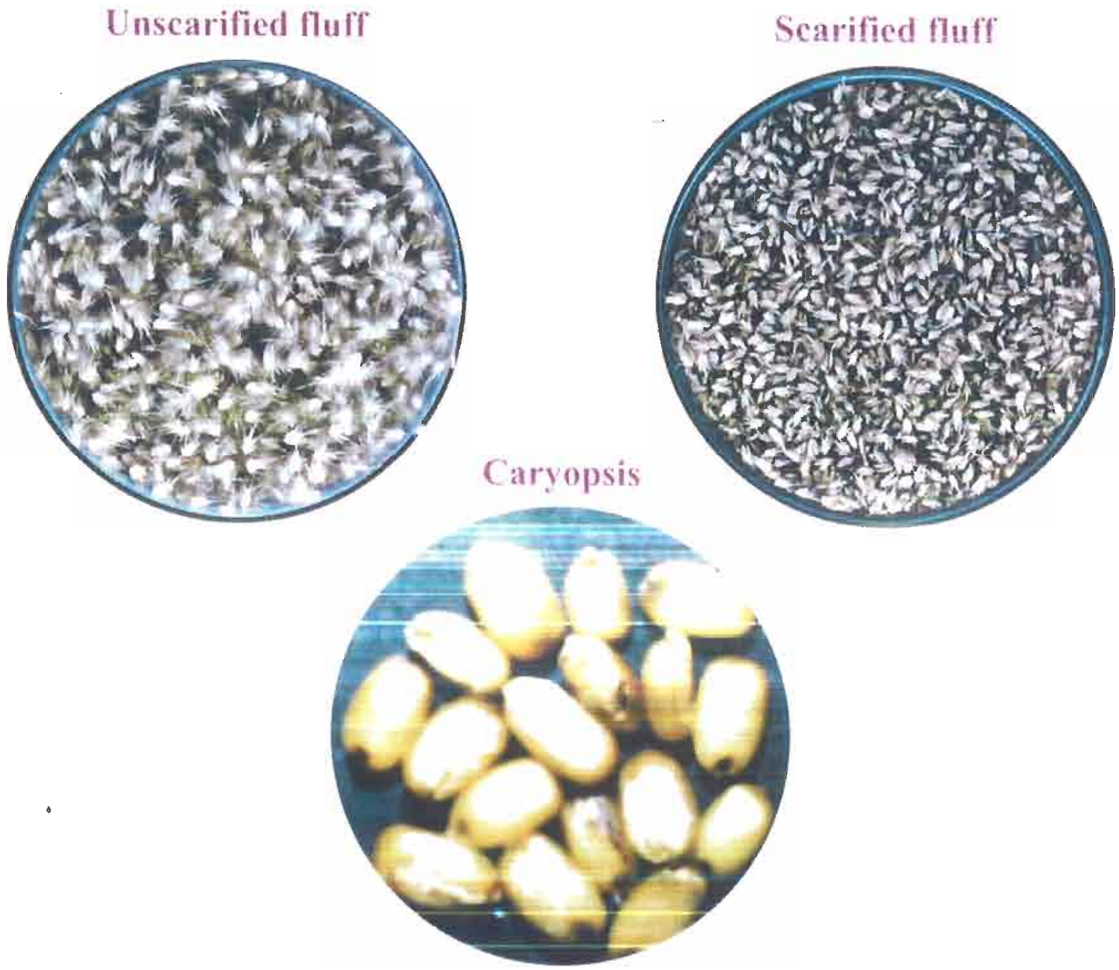


Plate 4. View of unscarified fluff, scarified fluff and caryopsis of *C.glaucus*

Plate 5. View of pelleted fluffs of *C.glaucus*

3.2.8.1.1. Germination

3.2.8.1.2. Root length

3.2.8.1.3. Shoot length

3.2.8.1.4. Vigour index

3.2.8.2. Field performance of pelleted seeds

3.2.8.2.1. Field emergence

Seeds were sown in a raised bed and the germination per cent was recorded after 14 days of germination period.

3.2.8.2.2. Fresh weight of seedling

From the field emergence plot, normal seedlings were collected after a period of 30 days and fresh weight of the seedlings were weighed accurately and expressed as gram seedling^{-1}.

3.2.8.2.3. Dry matter production

The seedlings used for fresh weight measurements were dried in a hot air oven at 85±2° for 16 h and cooled in a desiccator for 30 min. and weighed. The mean value was expressed as gram seedling^{-1}.

3.2.8.2.4. Vigour index

Vigour index was computed by multiplying percentage germination and dry matter production (g seeding^{-1}) and expressed as a whole number.

3.2.9. Storage studies

3.2.9.1. Fluff storage

One month old fluffs of *Cenchrus glaucus* were precleaned and dried to 10 per cent moisture content. One portion of seeds was scarified with H_2SO_4 for 4 min. as described earlier and dried to 10 per cent moisture content. Then one portion from each non-scarified and scarified fractions were treated with chlorine based halogen mixture

@ 3 g kg^{-1} of seed, containing dehydrated $CaOCl_2$ and dehydrated $CaCO_3$ in 2:1 ratio. The treated and untreated seeds of scarified and non scarified fluffs were packed in cloth or polythene (700 gauge) containers (heat sealed) and stored under ambient conditions.

Treatments

T_1	-	Fluffs / scarified fluffs stored without treatment
T_2	-	Fluffs/ scarified fluffs stored with treatment
C_1	-	Cloth bag
C_2	-	Polythene bag

Design : CRD

Replication : Four

The seeds were tested at bimonthly intervals which were represented as P_0, P_2, P_4, P_6, P_8, P_{10} and P_{12} for the following seed quality parameters :

3.2.9.1.1. Moisture content as detailed in 3.2.2.11

3.2.9.1.2. Germination as detailed in 3.2.6.4

3.2.9.1.3. Root length as detailed in 3.2.1.14

3.2.9.1.4. Shoot length as detailed in 3.2.1.15

3.2.9.1.5. Vigour index as detailed in 3.2.1.16

3.2.9.1.6. Electrical conductivity of leachate (Presley, 1958)

Fifty fluffs were taken at random from each treatment, prewashed with deionised water and soaked in 50 ml of deionized water for 5 h at room temperature. The seed steep water was then decanted and used to measure electrical conductivity in a digital conductivity meter having a cell constant of 1.0. The values were expressed as dSm^{-1}.

3.2.9.2. True seed storage

The true seeds extracted using commercial sulphuric acid (as described earlier) were treated with the halogen mixture. Treated and untreated seeds were packed in cloth or 700 gauge polythene bag (heat sealed) and stored under ambient conditions. The seeds were tested initially and subsequently at bimonthly intervals to assess the extent of loss in vigour and viability of seeds.

Treatments

T_1	-	Seeds without any treatment
T_2	-	Seeds treated with halogen mixture
C_1	-	Stored in cloth bag
C_2	-	Stored in polythene bag

Design : FCRD

Replication : Four

The following quality parameters were assessed as detailed in 3.2.9.1 at bimonthly intervals, designated as P_0, P_2, P_4, P_6, P_8, P_{10} and P_{12}.

3.2.9.2.1. Moisture content

3.2.9.2.2. Germination

3.2.9.2.3. Root length

3.2.9.2.4. Shoot length

3.2.9.2.5. Vigour index

3.2.9.2.6. Electrical conductivity

Statistical analysis

The data collected from various experiments were analysed statistically adopting the procedure described by Panse and Sukhatme (1995), wherever necessary, the per cent values were transformed to angular (arc sine) values. The critical differences (CD) were calculated at 5 per cent probability level. If the F test expressed is non-significant of variant, it was indicated by the letter NS.

Correlation studies

The RTD values were computed by the daily maximum and minimum temperature and the values were summed for each phenophase. Growing degree days (GDP), Helio thermal units (HTU) and photothermal units were computed by taking a base temperature of 10°C (Chatterjee and Das, 1989). The total sum of the values for each phenophase was obtained by using the following formulae.

$$\text{Accumulated GDD} = \sum_{1}^{N} [(T_{max} + T_{min})/2] - T_b$$

Where,

T_{max}, $T_{min.}$ - daily maximum and minimum temperature (°C)

T_b - base temperature (°C)

1 - date of sowing or start of phenophase

N - date of harvest or the end of phenophase

$$\text{Accumulated HTU} = \sum_{1} (\text{GDD}) * (\text{Sunshine hours})$$

$$\text{Accumulated PTU} = \sum_{1} (\text{GDD}) * (\text{Day length})$$

Subsequently correlation and stepwise regression analysis were performed using seed yields as dependent and agrometerological data as independent variables. Linear regression models based on phenophase-wise data pooled over four dates of sowing were derived for predicting the seed yield of a particular phenophase based on RTD, GDD, HTU and PTU values.

RESULTS

CHAPTER IV

RESULTS

4.1. Influence of dates of sowing and cutting treatments on seed yield and quality

4.1.1. Plant height (Table 1)

Plant height was significantly influenced by dates of sowing, cutting treatments and their interaction.

Plants sown at S_2 (129.36 cm) were the tallest, while that sown at S_1 (96.30 cm), the shortest.

Among the cutting treatments, C_2 (121.73 cm) and C_1 (117.81 cm) recorded more plant height than C_3 (113.1 cm).

In the interaction between sowing dates and treatments, S_2 at C_2 (144.2 cm) recorded maximum height, followed by S_3 at C_2 (138.23 cm), whereas minimum was in S_1 at C_2 (85.13 cm).

4.1.2. Days to first and 50 per cent flowering (Table 1)

Days required for the first and 50 per cent flowering varied significantly due to different dates of sowing, cutting treatments and their interaction.

S_1 took the shortest period of 38.6 and 44.8 days for the first and 50 per cent flowering respectively, while the longest was in S_3 (42.6 and 52.7 days) followed by S_2.

C_3 recorded less number of days (28.7 and 33.9) than C_1 (58.3 and 70.8) and C_2 (35.8 and 43.7) .

In S x C, S_3 and S_4 at C_3 registered the minimum values for the first and 50 per cent flowering while, S_3 at C_1 registered the maximum.

Table 1. Influence of dates of sowing and cutting treatments on plant height and days to first and 50 per cent flowering in *C. glaucus* cv. CO 1

Date of sowing	Plant height (cm)				Days to first flowering				Days to 50% flowering			
	C_1	C_2	C_3	M	C_1	C_2	C_3	M	C_1	C_2	C_3	M
S_1	102.47	85.13	101.30	96.30	50.0	35.0	30.7	38.6	58.0	41.7	34.7	44.8
S_2	116.93	144.20	126.93	129.36	58.0	37.0	30.7	41.9	70.1	48.3	36.3	51.6
S_3	130.33	138.23	103.20	123.92	64.0	36.0	27.7	42.6	80.3	44.7	33.0	52.7
S_4	121.53	119.33	120.97	120.61	61.0	35.3	25.7	40.7	75.0	40.0	30.3	48.4
M	117.81	121.73	113.10		58.3	35.8	28.7		70.8	43.7	33.9	Table

	S	C	SC		S	C	SC		S	C	SC
SE $\overline{d}$	2.203	1.908	3.816		0.704	0.610	1.220		0.963	0.834	1.669
CD ($P \leq 0.05$)	4.569	3.957	7.915		1.461	1.265	2.531		1.998	1.730	3.461

4.1.3. Number of tillers plant^{-1} (Table 2)

Number of tillers plant^{-1} showed significant differences among the dates of sowing and cutting treatments. Interaction effect was not significant.

Maximum number of tillers was recorded in S_3 (26.8), while minimum was in S_1 (20.9) which was on par with S_4 and S_2.

C_3 (23.7) and C_2 (23.5) registered more number of tillers than C_1 (20.7).

4.1.4. Number of fertile tillers plant^{-1} (Table 2)

Number of fertile tillers varied significantly due to dates of sowing, cutting treatments and their interaction.

The highest number of fertile tillers was observed in S_3 (18.2), which was on par with S_2 (17.62). The lowest was recorded in S_1 (12.8) followed by S_4 (14.66).

Among the treatments, C_2 registered maximum fertile tillers (19.82) followed by C_3 (14.86) and C_1, the minimum (12.73).

In S x C interaction, maximum number of fertile tillers was recorded in S_2 at C_2 (24.1), while the lowest was in S_1 at C_1 (8.1) which was on par with S_2 at C_3 and S_4 at C_1.

4.1.5. Spike length (Table 3)

Significant variations were observed in the length of the spike due to dates of sowing, cutting treatments and their interaction.

Among dates of sowing, S_2 registered maximum length of 10.86 cm followed by S_3 (10.76 cm), while the minimum was in S_1 (10.31cm), which was on par with S_4 (10.41 cm).

C_1 (10.79 cm) and C_2 (10.68 cm) recorded higher length of the spike than C_3 (10.29 cm).

Table 2. Influence of dates of sowing and cutting treatments on number of total and fertile tillers plant^{-1} in *C. glaucus* cv. CO 1

Dates of sowing	Number of tillers plant^{-1}				Number of fertile tillers plant^{-1}			
	C_1	C_2	C_3	M	C_1	C_2	C_3	M
S_1	19.9	19.0	23.8	20.9	8.10	15.13	15.13	12.80
S_2	20.2	22.4	20.7	21.1	17.14	24.13	11.60	17.62
S_3	23.7	28.2	28.4	26.8	14.50	20.10	20.10	18.20
S_4	18.8	24.3	22.0	21.7	11.13	19.90	12.60	14.66
M	20.7	23.5	23.7		12.73	19.82	14.86	

	S	C	SC		S	C	SC
SE$\overline{d}$	1.349	1.169	2.337		0.992	0.859	1.718
CD ($P \leq 0.05$)	2.799	2.423	NS		2.057	1.782	3.563

In the interaction of S x C, S_2 at C_1 registered the longest spike (11.39 cm) which was on par with S_1 at C_3, S_2 and S_3 at C_2 and S_4 at C_1. The shortest length was observed in S_4 at C_3 (9.70 cm) which was on par with S_1 at C_1 and C_2 and S_3 at C_3.

4.1.6. Spike weight (Table 3)

Spike weight showed significant differences among the dates of sowing, cutting treatments and their interaction.

Maximum spike weight was noticed in S_3 (447.7 mg) followed by S_4 (397.7 mg), while minimum was in S_1 (343.1 mg).

In cutting treatments, C_1 (447.5 mg) recorded more spike weight than C_3 (380.7 mg) and C_2 (378.2 mg).

In S x C interaction, S_2 at C_1 registered maximum spike weight of (503 mg), whereas minimum was in S_1 at C_2 (249.7 mg).

4.1.7. Number of fluffs spike^{-1} (Table 3)

Significant differences were observed in the number of fluffs spike^{-1} due to dates of sowing, cutting treatments and their interaction.

Among the dates of sowing, S_2 registered the highest number of fluff (163.8), while the lowest was in S_3 (144.0), which was on par with S_1 (147.6).

C_1 (160.5) and C_2 (158.5) registered more number of fluff than C_3 (135.5).

In S x C, S_2 at C_1 (173.9) recorded maximum number followed by S_2 at C_2 (167.7), whereas minimum was in S_3 at C_3 (106.7).

4.1.8. Fluff yield plot^{-1} (Table 4)

Fluff yield plot^{-1} was significantly influenced by dates of sowing, cutting treatments and their interaction.

Table 3. Influence of dates of sowing and cutting treatments on spike length, weight and number of fluff s spike^{-1} in *C. glaucus* cv. CO 1

Date of sowing	Spike length (cm)				Spike weight (mg)				Number of fluffs spike^{-1}			
	C_1	C_2	C_3	M	C_1	C_2	C_3	M	C_1	C_2	C_3	M
S_1	10.07	9.93	10.93	10.31	385.3	249.7	404.3	343.1	152.7	142.7	147.4	147.6
S_2	11.39	10.88	10.30	10.86	503.0	423.0	334.3	420.1	173.9	167.7	149.8	163.8
S_3	10.76	11.29	10.22	10.76	450.0	445.3	447.7	447.7	163.5	161.9	106.7	144.0
S_4	10.93	10.60	9.70	10.41	451.7	404.7	336.7	397.7	151.8	161.7	138.1	150.5
M	10.79	10.68	10.29		447.5	378.2	380.7	402.1	160.5	158.5	135.5	
	S	C	SC		S	C	SC		S	C	SC	
SE$\overline{d}$	0.158	0.137	0.274		12.89	11.17	22.33		2.584	2.237	4.475	
CD ($P \leq 0.05$)	0.328	0.284	0.569		26.74	23.16	46.31		5.359	4.641	9.281	

Maximum fluff yield of 185.47 g was recorded in S_2, while minimum was in S_4 (94.56 g).

Among cutting treatments, higher yield was observed in C_1 (166.96 g) than C_3 (122.80 g) and C_2 (115.95 g).

In the interaction of S x C, S_2 at C_1 registered maximum fluff yield (345.17 g), whereas S_2 at C_3 registered the minimum (55 g).

4.1.9. Pure fluff yield plot^{-1} (Table 4)

Significant differences were observed in pure fluff yield plot^{-1} due to different dates of sowing, cutting treatments and their interactions.

Among dates of sowing, the highest pure fluff yield was observed in S_2 (161.94 g) and the lowest in S_4 (79.26g).

C_1 registered the highest yield (148.51 g) followed by C_3 (99.83 g), while C_2 recorded the lowest yield (99.07 g).

In S x C, maximum pure fluff yield was recorded in S_2 at C_1 (307.70 g), whereas minimum was in S_2 at C_3 (44.50 g).

4.1.10. Fluff yield ha^{-1} (Table 4)

Computed fluff yield ha^{-1} showed significant differences due to different dates of sowing, cutting treatments and their interaction.

S_2 recorded maximum yield (134.93 kg) and S_4, the minimum (66.03 kg).

C_1 recorded more yield (123.74 kg) than C_3 (83.19 kg) and C_2 (82.54 kg).

In the interaction of S x C, the highest fluff yield of 256.37 kg was recorded at S_2C_1, while the lowest was in S_2 at C_3 (37.10 kg).

Table 4. Influence of dates of sowing and cutting treatments on fluff yield in *C. glaucus* cv. CO 1

Dates of sowing	Fluff yield $plot^{-1}$ (g)				Pure fluff yield $plot^{-1}$ (g)				Fluff yield kg ha^{-1}			
	C_1	C_2	C_3	M	C_1	C_2	C_3	M	C_1	C_2	C_3	M
S_1	98.83	95.30	222.17	138.77	88.83	81.48	182.27	117.53	74.03	67.90	151.90	97.94
S_2	345.17	156.17	55.00	185.47	307.7	133.63	44.50	161.94	256.37	111.33	37.10	134.93
S_3	129.17	105.33	132.33	122.28	114.97	90.87	107.60	104.48	95.80	75.70	89.67	87.06
S_4	94.67	107.00	82.00	94.56	82.53	90.30	64.93	79.26	68.77	75.23	54.10	66.03
M	166.96	115.95	122.80	115.80	148.51	99.07	99.83	115.80	123.74	82.54	83.19	

	S	C	SC		S	C	SC		S	C	SC
SE $\overline{d}$	5.99	5.18	10.37		5.03	4.35	8.71		4.19	3.62	7.25
CD ($P \leq 0.05$)	12.41	10.75	21.55		10.43	9.03	18.06		8.69	7.52	15.04

4.1.11. Ill filled fluff (Table 5)

Percentage occurrence of ill filled fluffs showed significant variation due to cutting treatments and the interaction between dates of sowing and cutting treatments.

Among the treatments, C_3 (19.75 per cent) recorded maximum ill filled fluffs followed by C_2 (15.15 per cent) and C_1 (12.72 per cent), the minimum.

In the interaction between S x C, maximum ill filled fluffs was observed in S_2 at C_3 (22.93 per cent), while the minimum was in S_2 at C_1 (11.4 per cent).

4.1.12. Hundred fluff weight (Table 5)

Hundred seed weight was significantly influenced by dates of sowing, cutting treatments and their interaction.

Maximum 100 fluff weight was noticed in S_3 (228.8 mg), followed by S_2 (220.3 mg), while minimum was in S_1 (182.7 mg) which was on par with S_4.

Among cutting treatments, higher fluff weight was recorded in C_1 (232.6 mg), than in C_3 (204 mg) and C_2 (179.3 mg).

In S x C, S_2 at C_1 registered the highest fluff weight of 270 mg, followed by S_3 at C_3 (266.7 mg), whereas the lowest was in S_1 at C_2 (140.0 mg) which was on par with S_4 at C_3.

4.1.13. Germination (Table 5)

Seed germination exhibited significant differences due to cutting treatments and their interaction with dates of sowing.

C_1 and C_2 registered higher germination (73 and 71 per cent respectively) than C_3 (61 per cent).

In S x C, maximum germination of 75 per cent was recorded in S_2 at C_1 which was on par with S_2 at C_2, S_4 at C_1 and S_4 at C_2. Minimum was recorded in S_2 at C_3 (50 per cent).

Table 5. Influence of dates of sowing and cutting treatments on ill filled seed, hundred fluff weight and seed germination in *C. glaucus* cv. CO 1

Dates of sowing	Ill filled fluff (%)				100 fluff weight (mg)				Germination (%)			
	C_1	C_2	C_3	M	C_1	C_2	C_3	M	C_1	C_2	C_3	M
S_1	13.23	14.55	17.87	15.21	195.0	140.0	213.0	182.7	70 (56.79)	71 (57.21)	67 (55.15)	69 (56.38)
S_2	11.40	14.87	22.93	16.40	270.0	209.7	181.3	220.3	75 (60.25)	75 (60.02)	50 (44.81)	67 (55.02)
S_3	13.10	15.27	19.53	15.97	247.7	172.0	266.7	228.8	71 (57.22)	68 (55.35)	68 (55.35)	69 (55.97)
S_4	13.17	15.93	18.67	15.92	217.6	195.3	155.0	189.3	75 (60.25)	72 (57.86)	58 (49.80)	68 (55.97)
M	12.72	15.15	19.75		232.6	179.3	204.0	205.3	73 (58.63)	71 (57.61)	61 (51.27)	

	S	C	SC	S	C	SC	S	C	SC
SE $\bar{d}$	0.467	0.402	0.803	4.45	3.86	7.71	0.77	0.67	1.33
CD ($P \leq 0.05$)	NS	0.832	1.666	9.23	8.00	15.99	NS	1.38	2.76

(Figure in parentheses are arc sine values)

4.1.14. Root length (Table 6)

Significant differences were noticed in root length of the seedling due to cutting treatments and their interaction with dates of sowing.

Among cutting treatments, C_1 (5.87 cm) and C_2 (5.59 cm) registered longer root than C_3 (5.10 cm).

In S x C interaction, S_4 at C_1 (6.04 cm) recorded the highest root length which was on par with S_4 at C_2, S_1 at C_1 and C_3, S_2 at C_1 and C_2 and S_3 at C_1. The shortest root was observed in S_2 at C_3 (4.26 cm).

4.1.15. Shoot length (Table 6)

Shoot length was significantly influenced by dates of sowing and cutting treatments. Interaction effect was not significant.

S_1 registered maximum shoot length of 6.19 cm followed by S_3 (5.86 cm) whereas the minimum was in S_2 (5.46 cm).

Among cutting treatments, the longest root was in C_1 (6.34 cm) and the shortest in C_3 (5.22 cm).

4.1.16. Vigour index (Table 6)

Vigour index values varied significantly due to different dates of sowing, cutting treatments and their interaction.

The computed vigour index value was the highest in S_1 (818) which was on par with S_3 and S_4. The lowest vigour index was in S_2 (734).

C_1 recorded maximum value (889) and minimum was in C_3 (633).

In S x C interaction, S_2 at C_1 (890) recorded maximum which was on par with S_1C_1, S_2C_2, S_3C_1 and S_4C_1.

Table 6. Influence of dates of sowing and cutting treatments on root and shoot length of seedlings and vigour index in *C. glaucus* cv. CO 1

Dates of sowing	Root length (cm)				Shoot length (cm)				Vigour index			
	C_1	C_2	C_3	M	C_1	C_2	C_3	M	C_1	C_2	C_3	M
S_1	5.95	5.33	5.50	5.59	6.58	6.18	5.81	6.19	878	815	762	818
S_2	5.62	5.98	4.26	5.29	6.20	5.70	4.48	5.46	890	876	434	734
S_3	5.86	5.35	5.24	5.48	6.34	5.82	5.43	5.86	862	755	722	780
S_4	6.04	5.71	5.42	5.73	6.26	5.47	5.15	5.62	926	803	613	781
M	5.87	5.59	5.10		6.34	5.79	5.22		889	812	633	

	S	C	SC		S	C	SC		S	C	SC
SE$\bar{d}$	0.161	0.139	0.279		0.229	0.198	0.397		19.47	16.86	33.73
CD ($P \leq 0.05$)	NS	0.289	0.579		0.475	0.411	NS		40.39	34.97	69.95

4.2. Seed development and maturation

All the parameters showed highly significant differences among stages of maturity, positions of spikelets and their interaction except the number of fluffs spike^{-1} at different maturity stages.

4.2.1. Spike length (Table 7)

Significant increase in spike length was observed upto 12 DAA beyond which the increase was not significant.

4.2.2. Number of fluffs spike^{-1} (Table 7)

Spikelets from the middle portion of the spike registered maximum number (40.93) followed by the distal portion (38.04) and proximal portion had the minimum (30.21).

In the interaction of D x P, spikelets of distal portion at D_6 registered the maximum, which was on par with D_3P_2, D_3P_3, D_6P_3, D_6D_2, D_9P_3, D_9P_2, $D_{12}P_3$, $D_{12}P_2$, $D_{15}P_2$, $D_{18}P_2$ and $D_{21}P_2$. Spikelets from proximal portion at D_3 and D_9 registered the minimum.

4.2.3. Fresh weight of spike (Table 8)

Irrespective of the portion, three day old spike (D_3) recorded the highest fresh weight of 198.3 mg, which decreased gradually, attained the minimum at D_{12} (83.5 mg), increased again at D_{15} (121.6 mg) and thereafter declined gradually recording 110 mg at D_{21}.

Among the portions, proximal portion registered the highest fresh weight (148 mg) compared to middle (127.8 mg) and distal portion of the spike (70.4 mg).

In D x P, three day old (D_3) spike from proximal portion recorded maximum fresh weight (253 mg) while 12 day old spike (D_{12}) from distal portion recorded the minimum (54.2 mg).

Table 7. Spike length and number of fluffs spike^{-1} as influenced by stages of seed maturation in *C. glaucus* cv. CO 1

Stages of maturation	Spike Length (cm)	Number of fluffs spike^{-1}				
		P_1	P_2	P_3	Total	Mean
D_3	9.13	26.0	38.25	40.50	104.8	34.92
D_6	9.43	30.0	43.75	44.25	118.0	39.33
D_9	10.03	27.50	41.50	40.0	119.0	39.66
D_{12}	10.80	33.75	42.5	39.0	115.3	38.42
D_{15}	10.70	35.75	39.5	33.75	109.0	36.30
D_{18}	10.66	33.50	40.0	34.75	108.3	36.08
D_{21}	10.56	35.0	41.0	34.0	110.0	36.67
Mean	10.21	30.21	40.93	38.04		

		D	P	DP
SE$\bar{d}$	0.392	2.203	1.442	3.816
CD ($P \leq 0.05$)	0.841	NS	2.885	7.634

4.2.4. Dry weight of spike (Table 8)

Spike at D_{21} recorded the maximum dry weight (99.7 mg) followed by spike at D_{15} and D_{18}, whereas minimum was in six day old (D_6) spike (44.2 mg).

Irrespective of the maturity stages, proximal portion registered more dry weight (99.3 mg) than middle (82.4 mg) and distal portion of the spike (49.1 mg).

In the interaction between stages of maturity and portion of spike, 21 day old (D_{21}) spike from proximal portion (144 mg) recorded maximum dry weight, followed by D_{18} and D_{15} (141.5 and 130.3 mg respectively), while 6 day old (D_6) spike from distal portion registered the minimum (28.8 mg).

4.2.5. Fresh weight of fluff (Table 9)

Irrespective of portion, three day old spikelets recorded the lowest fresh weight of 225.9 mg and it reached the highest of 284.8 mg at 15 DAA and thereafter declined gradually to 259.3 mg at 21 DAA (D_{21}).

Proximal portion spikelets registered the highest fresh weight of 317.1 mg, followed by middle portion (258.7 mg) and the distal portion registered the least (187.1 mg).

In D x P, 18 day old spikelets from proximal portion recorded maximum fresh weight (355 mg), followed by D21 and D15 (354.3), whereas three day old spikelets (D_3) from distal portion recorded the minimum (162.3 mg).

4.2.6. Dry weight of fluff (Table 9)

Spikelets at 18 DAA registered maximum dry weight of 256 mg, followed by D_{21} and D_{15} (248.8 mg), while minimum was recorded at D_3 (109.4 mg).

Irrespective of maturity stages, spikelets from proximal portion recorded higher dry weight (257.4 mg) compared to middle (205 mg) and distal (149.9 mg) portions.

Table 8. Fresh and dry weight of spike during stages of seed maturation in *C. glaucus* cv. CO 1

Stages of maturation	Fresh weight of spike (mg)				Dry weight of spike (mg)			
	P_1	P_2	P_3	M	P_1	P_2	P_3	M
D_3	253.0	226.5	115.0	198.3	102.5	92.0	52.5	82.3
D_6	102.3	114.8	58.50	91.8	47.0	56.7	28.8	44.2
D_9	99.8	107.3	65.50	90.8	53.0	59.5	39.8	50.8
D_{12}	101.3	95.0	54.20	83.5	76.5	71.5	42.5	63.5
D_{15}	165.0	128.3	71.50	121.6	130.3	106.0	62.3	99.5
D_{18}	158.5	110.5	65.00	111.3	141.5	94.8	59.3	98.5
D_{21}	155.0	112.0	63.00	110.0	144.0	96.0	59.0	99.7
M	147.9	127.8	70.40	115.3	99.3	82.4	49.1	76.9

	D	P	DP		D	P	DP
SE$\bar{d}$	5.71	3.74	9.9		4.68	3.06	8.10
CD ($P \leq 0.05$)	11.43	7.48	19.8		9.40	6.12	16.20

Table 9. Fresh and dry weight of fluffs during seed development and maturation in *C. glaucus* cv. CO 1

Stages of maturation	Fresh weight of fluffs (mg)				Dry weight of fluffs (mg)			
	P_1	P_2	P_3	M	P_1	P_2	P_3	M
D_3	307.5	208.0	162.3	225.9	146.8	102.3	79.3	109.4
D_6	281.8	245.3	184.5	237.2	162.8	139.5	92.0	131.4
D_9	273.0	264.3	199.8	245.7	220.3	194.3	162.3	192.3
D_{12}	310.8	291.8	202.8	268.4	277.0	251.5	177.8	235.4
D_{15}	337.8	294.0	222.8	284.8	294.3	250.0	202.3	248.8
D_{18}	355.0	252.5	169.5	259.0	350.8	249.8	167.5	256.0
D_{21}	354.3	255.3	168.5	259.3	350.0	247.5	168.0	255.0
M	317.1	258.7	187.1	254.3	257.4	205.0	149.9	

	D	P	DP		D	P	DP
SEd	6.59	4.31	11.41		5.18	3.39	8.97
CD ($P \leq 0.05$)	13.18	8.63	22.83		10.36	6.78	17.94

In D x P, the highest dry weight of 350.8 mg was recorded in D_{18} at P_1 followed by D_{21} at P_1 (350 mg) whereas it was minimum at D_3 at P_3 (79.3 mg).

4.2.7. Moisture content of spike (Table 10)

The highest moisture content of 58.9 per cent registered at D_3, which declined gradually and reached the minimum (10.36 per cent) at 21 DAA (D_{21}).

Middle and proximal portion spikes recorded more moisture than the distal portion.

In the interaction between days of maturity and portion of spike, in all portions spike at 3 D AA (D_3) registered the highest moisture, while the lowest was in distal end at D_{21} (8.95 per cent) followed by D_{18} (9.03 per cent).

4.2.8. Moisture content of fluff (Table 10)

Spikelets at three DAA (D_3) registered maximum moisture (52.12 per cent), which declined gradually and reached the minimum (9.23 per cent) at 21 DAA.

Spikelets from middle (28.47 per cent) and proximal (27.86 per cent) portions recorded higher moisture than distal portion spikelets (27.18 per cent).

In D x P the highest moisture was recorded at D_3 from all portions of the spike, whereas 21 day old spikelets from distal portion recorded the minimum (5.34 per cent) which was on par with D_{18} at P_3 (5.46 per cent).

4.2.9. Number of seeds fluff^{-1} (Table 11)

Irrespective of the portions, fluffs at 18 and 21 DAA contained maximum number of true seeds (1.98) while D_3, the minimum (0.367).

Spikelets from the proximal portion had more number of seeds (2.17) than middle (1.50) and distal (0.71) portions.

Table 10. Moisture content of spike and fluffs during seed development and maturation in *C. glaucus* cv. CO 1

Stages of maturation	Moisture content of spike (%)				Moisture content of fluff (%)			
	P_1	P_2	P_3	M	P_1	P_2	P_3	M
D_3	59.60	59.59	57.50	58.90	56.67	56.17	58.50	52.12
D_6	55.52	55.05	54.20	54.92	46.08	46.98	55.57	49.54
D_9	46.64	42.08	39.57	42.76	28.19	32.47	28.20	29.62
D_{12}	24.50	24.75	22.29	23.85	21.12	23.04	24.13	22.76
D_{15}	21.13	17.39	13.07	17.20	21.13	17.39	13.07	17.20
D_{18}	10.69	12.28	9.03	10.67	10.94	11.77	5.46	9.39
D_{21}	10.50	11.64	8.95	10.36	10.87	11.48	5.34	9.23
M	32.65	31.82	29.23		27.86	28.47	27.18	

	D	P	DP		D	P	DP
SE$\overline{d}$	0.478	0.313	0.827		0.528	0.346	0.915
CD ($P \leq 0.05$)	0.955	0.625	1.654		1.056	0.692	1.830

In D x P, spikelets from proximal portion at 18 and 21 DAA recorded maximum number of seeds (3.0) and it was the least in D_3 at P_2 (0.48).

4.2.10. Number of filled seeds fluff^{-1} (Table 11)

Filled seeds were maximum at D_{21} (1.83) followed by D_{18} (1.78) and D_{15} (1.69), whereas it was minimum at D_6 (0.342).

Among portions, proximal portion (1.69) registered the highest number of filled seeds, followed by middle portion (1.27), while the lowest was in distal portion (0.44).

In D x P, maximum number of seeds were at proximal end at 18 and 21 DAA, while minimum was in middle portion at 6 DAA. Distal portion at D_6 and D_3 did not contain any filled seed at all.

4.2.11. Number of ill filled seeds fluff^{-1} (Table 11)

The minimum number of ill filled seed was recorded at D_{21} (0.17) followed by D_{18} (0.22) and it was maximum at D_{12} (0.6) and D_9 (0.57).

Proximal portion recorded minimum number of ill filled seeds (0.33) followed by middle portion and it was maximum at distal end (0.49).

In D x P, the lowest number of ill filled seeds was recorded in P_1 at D_{21} (0.1), which was on par with P_2 at D_{21}, P_3 at D_{21}, P_1 at D_{18}, P_2 at D_{18}, P_3 at D_{18} and P_2 at D_{15} and the highest was observed in P_1 at D_9 (0.8) which again was on par with P_1 at D_{12} (0.75).

4.2.12. Hundred true seed weight (Table 12)

The highest seed weight was registered at D_{15} (71.7 mg) and the lowest in D_3 (24.2 mg).

Middle portion recorded more seed weight (69.0 mg), than the proximal (65.8 mg) and distal (45.7 mg) portions.

Table 11. Number of seeds fluff^{-1}, filled and ill filled seeds fluff^{-1} during seed development and maturation in C. *glaucus* cv. CO 1

Stages of maturation	Number of seeds fluff^{-1}				Number of filled seeds fluff^{-1}				Number of ill filled seed fluff^{-1}			
	P_1	P_2	P_3	M	P_1	P_2	P_3	M	P_1	P_2	P_3	M
D_3	0.63	0.48	0.00	0.37	0.0	0.0	0.00	0.0	0.65	0.48	0.00	0.38
D_6	1.10	0.75	0.25	0.70	0.53	0.51	0.00	0.34	0.45	0.58	0.23	0.42
D_9	2.05	1.45	0.70	1.40	1.30	1.00	0.38	0.89	0.80	0.50	0.40	0.57
D_{12}	2.50	1.95	1.00	1.82	1.80	1.80	0.58	1.39	0.75	0.50	0.55	0.60
D_{15}	2.90	1.95	1.00	1.95	2.53	1.85	0.70	1.69	0.50	0.25	0.55	0.43
D_{18}	3.0	1.95	1.00	1.98	2.80	1.85	0.70	1.78	0.20	0.50	0.30	0.22
D_{21}	3.0	1.95	1.00	1.98	2.90	1.90	0.70	1.83	0.10	0.13	0.28	0.17
M	2.17	1.50	0.71		1.69	1.27	0.44		0.49	0.37	0.33	

	D	P	DP		D	P	DP		D	P	DP	
SE $\bar{d}$	0.069	0.045	0.119		0.075	0.049	0.130		0.071	0.046	0.123	
CD ($P \leq 0.05$)	0.138	0.090	0.239		0.150	0.098	0.260		0.142	0.927	0.245	

In the interaction of D x P, 15 day old seeds from middle portion registered maximum seed weight (81.0 mg) followed by 18 day old seeds (80.5) whereas minimum was in D_3 at P_1 (33.3 mg).

4.2.13. Germination (Table 12)

A gradual improvement in germination was observed with advances in period of seed development and the highest germination was recorded from the seeds obtained at later stages of development and maturation (76 per cent at 21 DAA), while the lowest was at D_{12} (12 per cent). The immature seeds at early stage of development did not germinate (3, 6 and 9 DAA).

Among portions, middle portion recorded maximum germination (36 per cent), followed by proximal portion (35 per cent) and minimum was in distal portion (26 per cent).

In D x P, 21 day old spikelets from middle portion registered maximum germination of 80 per cent followed by D_{21} at P_1 and D_{18} at P_2. It was minimum in D_{12} at P_1 (17.0 per cent) followed by D_{12} at P_2 (18.0 per cent).

4.3. Seed quality in relation to tillers

4.3.2. Length of the spike (Table 13)

Length of the spike varied significantly among the tillers.

T_4 and T_8 recorded the maximum length of 7.3 cm and T_7, the minimum (4.84 cm). The spike length was on par from T_1 to T_6.

4.3.2. Weight of the spike (Table 13)

The differences in spike weight among tillers was significant.

Maximum spike weight was registered in T_5 (235.6mg) followed by T_4 (232.2mg). Minimum of 132.0mg was recorded in T_7.

Table 12. True seed weight and germination during seed development and maturation in *C. glaucus* cv. CO 1

Stages of maturation	Weight of 100 true seeds (mg)				Germination (%)			Mean
	P1	P2	P3	Mean	P1	P2	P2	
D_3	33.3	39.3	0	24.2	0	0	0	0 (0.313)
D_6	68.0	52.8	49.3	56.7	0	0	0	0 (0.313)
D_9	65.0	73.3	53.8	64.0	0	0	0	0 (0.313)
D_{12}	75.0	77.8	54.3	69.0	17 (23.93)	18 (25.27)	0	12 (16.50)
D_{15}	77.3	81.0	56.7	71.7	71 (57.44)	72 (58.07)	49 (44.43)	64 (53.31)
D_{18}	72.2	80.5	54.0	68.9	77 (61.04)	79 (62.41)	64 (52.54)	73 (58.76)
D_{21}	69.8	78.5	52.0	66.8	78 (62.05)	80 (63.27)	70 (56.67)	76 (60.66)
Mean	65.8	69.0	45.7		35 (29.34)	36 (29.99)	26 (22.17)	

	D	P	DP		D	P	DP
SE $\bar{d}$	0.93	0.61	1.61		0.541	0.354	0.936
CD ($P \leq 0.05$)	1.86	1.22	3.22		1.082	0.708	1.873

Figures in parenthesis are arc sine values

4.3.3. Number of fluffs spike^{-1} (Table 13)

Number of fluffs spike^{-1} showed non significant variations among different tillers and it ranged from 51 in T_7 to 70 in T_6.

4.3.4. Number of seeds fluff^{-1} (Table 13)

Number of seeds fluff^{-1} differed significantly among tillers.

Maximum number of seeds was noticed in T_1 (1.55) and it gradually declined in the late formed tillers and reached minimum of 0.92 at T_7.

4.3.5. Hundred fluff weight (Table 13)

Weight of fluff showed significant variations among tillers. Fluffs from T_4 registered the highest weight (333.8mg) followed by T_3 (322.3mg), whereas T_7 registered the lowest (227.8 mg) which was on par with T_2 (252.5mg).

4.3.6. Germination of true seeds (Table 13)

4.3.6.1. Large seeds

Large seeds from T_1 registered the highest germination of 83 per cent, which was followed by T_2, T_3, T_4 and T_5. T_7 registered the lowest (40 per cent) followed by T_8 (52 per cent).

4.3.6.2. Small seeds

T_1 recorded the maximum germination (64 per cent) followed by T_2 (49 per cent) whereas T_7, the minimum (17 per cent).

4.3.7. Dormancy level of stored fluffs (Table 14)

The effect of tillers, period of storage and their interactions were significant.

Seeds from T_1 registered maximum germination of 43 per cent followed by T_2 (42 per cent). T_7 registered the minimum (17 per cent).

Table 13. Spike and seed quality characters as influenced by tillers in *C. glaucus* cv. CO 1

Tillers in sequence	Spike length (cm)	Spike weight (mg)	Number of fluff $spike^{-1}$	Number of seeds $fluff^{-1}$	100 fluff weight (mg)	True seed germination (%)	
						Large seeds	Small seeds
T_1	6.88	192.0	64	1.55	322.0	83 (65.51)	64 (53.33)
T_2	6.40	200.6	55	1.34	252.5	81 (64.39)	49 (44.61)
T_3	7.08	222.6	59	1.44	322.3	81 (64.00)	30 (33.20)
T_4	7.32	232.2	67	1.41	333.8	81 (63.99)	32 (34.23)
T_5	6.72	235.6	68	1.40	305.3	79 (62.41)	28 (32.14)
T_6	6.98	209.0	70	1.39	295.0	73 (58.56)	29 (32.35)
T_7	4.84	132.0	51	0.92	227.8	40 (39.20)	17 (24.54)
T_8	6.52	143.6	58	1.18	247.8	52 (46.14)	29 (32.35)
M	6.59	196.0	62	1.33	288.3	69 (58.02)	35 (35.84)
SE$\overline{d}$	0.407	0.027	7.049	0.090	13.5	1.488	1.516
CD ($P \leq 0.05$)	0.834	0.056	NS	0.185	27.7	3.095	3.154

Figures in parentheses are arc sine values

Table 14. Seed germination (%) as influenced by tillers and periods of storage in *C. glaucus* cv. CO 1

Tillers in sequence	Period of storage				
	P_0	P_1	P_2	P3	Mean
T_1	0 (0.31)	48 (43.85)	53 (46.72)	70 (57.00)	43 (36.96)
T_2	2 (8.13)	41 (39.77)	51 (45.57)	72 (58.06)	42 (37.32)
T_3	0 (0.31)	38 (37.99)	50 (45.00)	72 (58.23)	40 (36.37)
T_4	0 (0.31)	20 (26.63)	55 (47.80)	76 (60.33)	38 (33.77)
T_5	0 (0.31)	13 (21.0)	57 (48.91)	85 (66.92)	39 (34.27)
T_6	0 (0.31)	10 (18.40)	58 (49.62)	82 (64.93)	37 (33.30)
T_7	0 (0.31)	6 (14.05)	33 (34.86)	30 (33.13)	17 (20.50)
T_8	1.0 (5.74)	43 (40.80)	45 (42.11)	44 (41.69)	33 (31.92)
M	0.37 (1.31)	27 (30.31)	50 (45.08)	66 (55.04)	

	T	P	TP
SE$\overline{d}$	1.07	0.75	2.14
CD ($P \leq 0.05$)	2.13	1.50	4.26

Figures in parentheses are arc sine values

Fluffs did not germinate at P_0 stage. The dormancy of seeds dissipated slowly and the peak mean germination of 66 per cent occurred after nine months of storage.

In the interaction between T and P, T_5 and T_6 at P_4 registered the maximum germination and T_7 at P_2, the minimum (6 per cent).

4.4. Germination test requirements

4.4.1. Days to first emergence (Table 15)

Days required for the first emergence of radicle varied significantly with temperature, media and their interaction.

Among the different temperature levels, the lowest value of two days was recorded in T_3 whereas the highest was in T_1 (5.42).

M_2 recorded minimum number of days (2.33) than M_1 (3.08) and M_3 (4.75).

In the interaction between temperature and media, T_3 at M_2 recorded the minimum number of days (1), while maximum was in M_3 at T_1 (8).

4.4.2. Speed of germination (Table 15)

Speed of germination was significantly influenced by temperature, media and their interaction.

The fastest germination was observed in T_3 (28.43), while the slowest was in T_5 (1.18).

Among media, M_2 registered higher value of 25.19 than M_1 (16.58) and M_3 (13.28).

In TxM, the highest germination was recorded in T_3 at M_2 (39.45) followed by T_6 at M_2 (37.04), whereas the lowest of 1.0 in T_5 at M_2.

4.4.3. Germination (Table 15)

Germination showed significant differences due to temperature, media and their interaction.

Table 15. Effect of temperature and media on days to first emergence, speed of germination and germination of seeds in *C. glaucus* cv. CO 1

Treatments	Days to first emergence				Speed of Germination				Germination (%)			
	M_1	M_2	M_3	M	M_1	M_2	M_3	M	M_1	M_2	M_3	M
T_1	5.25	3.0	8.0	5.42	4.87	13.13	7.39	8.46	29 (32.53)	55 (48.06)	63 (52.63)	49 (44.4)
T_2	2.5	2.0	4.0	2.83	18.91	29.79	17.31	22.00	58 (49.65)	76 (61.11)	78 (62.32)	71 (57.69)
T_3	2.0	1.0	3.0	2.0	23.26	39.45	22.58	28.43	22 (27.95)	18 (24.36)	43 (40.97)	28 (31.09)
T_4	2.0	2.0	4.0	2.67	25.48	30.70	14.39	23.52	82 (64.71)	83 (65.50)	80 (63.44)	82 (64.55)
T_5	4.75	4.0	6.0	4.92	0.50	1.00	2.05	1.18	13 (20.88)	20 (26.51)	60 (50.80)	31 (32.73)
T_6	2.0	2.0	3.5	2.5	26.48	37.04	15.96	26.49	78 (62.15)	79 (62.94)	76 (60.77)	78 (61.95)
M	3.08	2.33	4.75		16.58	25.19	13.28		47 (42.98)	55 (48.08)	67 (55.16)	

	T	M	TM	T	M	TM	T	M	TM
SE$\bar{d}$	0.18	0.13	0.33	0.96	0.67	1.66	1.63	1.15	2.82
CD ($P \leq 0.05$)	0.38	0.27	0.65	1.92	1.35	3.32	3.26	2.31	5.65

Figures in parentheses are arc sine values

The highest germination of 82 per cent was observed in T_4 followed by T_6 (78 per cent), whereas the lowest of 28 per cent in T_3 which was on par with T_5 (31 per cent).

M_3 registered more germination (67 per cent) than M_2 (55 per cent) and M_1 (47 per cent).

In the interaction of TxM, T_4 at M_2 recorded the highest germination (83 per cent) which was on par with T_2 at M_2 and M_3. The lowest value was recorded in T_3 at M_2 (18 per cent) which was on par with T_5 at M_1 and M_2.

4.4.4. Root length (Table 16)

Significant differences were observed due to temperature, media and their interactions.

Maximum root length of 4.64 cm was noticed in T_6 which was on par with T_3 (4.56 cm) and T_4 (4.43 cm), while the shortest in T_5 (2.79 cm).

M_2 and M_3 registered more root length (4.70cm) than M_1 (2.47cm).

In TxM, the lengthiest root was recorded in T_3 at M_3 (5.72 cm), which was on par with T_2 at M_2 and T_4 and T_6 at M_3. The shortest root was recorded in T_1 at M_1, (2.25cm) which was on par with T_2 and T_4 at M_1.

4.4.5. Shoot length (Table 16)

Shoot length showed significant variations among temperature, media and their interaction.

Among temperature levels, maximum shoot length was recorded in T_6 (7.20cm), followed by T_3 (7.06 cm), whereas minimum in T_5 (3.91cm).

Shoot length of M_3 (6.19cm) and M_2 (6.11 cm) were higher compared to M_1 (4.58 cm).

Table 16. Effect of temperature and media on root and shoot length of seedlings and vigour index in *C. glaucus* cv. CO 1

Treatments	Root length (cm)				Shoot length (cm)				Vigour index			
	M_1	M_2	M_3	M	M_1	M_2	M_3	M	M_1	M_2	M_3	M
T_1	2.25	4.31	3.80	3.45	3.77	4.86	4.97	4.53	178	508	557	414
T_2	2.63	5.43	3.81	3.96	4.70	5.20	5.87	5.25	424	811	752	662
T_3	2.95	5.00	5.72	4.56	5.60	7.64	7.95	7.06	196	219	589	335
T_4	2.73	4.89	5.67	4.43	4.54	6.75	6.11	5.80	595	959	943	832
T_5	1.18	3.77	3.43	2.79	3.35	4.33	4.05	3.91	59	162	447	223
T_6	3.05	5.10	5.78	4.64	5.53	7.85	8.21	7.20	672	1029	1061	921
M	2.47	4.75	4.70		4.58	6.11	6.19		354	615	725	

	T	M	TM	T	M	TM	T	M	TM
$SE\bar{d}$	0.155	0.110	0.269	0.209	0.148	0.363	30.61	21.65	53.02
CD ($P \leq 0.05$)	0.311	0.220	0.538	0.420	0.297	0.728	61.37	43.40	106.30

In the interaction of TxM, the longest shoot was observed in T_3 at M_3 (7.95cm), which was on par with T_3 at M_2 and T_6 at M_2 and M_3. The lowest value was observed in T_5 at M_1 (3.35 cm) which was on par with T_5 at M_3 (4.05 cm) and T_1 at M_1 (3.77 cm).

4.4.6. Vigour index (Table 16)

Significant variations were observed in vigour index due to temperature, media and their interaction.

Maximum vigour index was registered in T_6 (921) and minimum in T_5 (223).

M_3 recorded more vigour index (725) than M_2 (615) and M_1 (354).

In TxM, maximum vigour index of 1061 was observed in T_6 at M_3 which was on par with T_6 at M_2 (1029) and T_4 at M_2 (959) while minimum was in T_5 at M_1 (59).

4.5. Methods of true seed extraction

Methods of seed extraction exerted significant influence on all the parameters studied except root length and viable seed per cent.

4.5.1. Seed recovery (Table 17)

Seed recovery under manual defluffing was the highest (28 per cent). The next best treatments were mechanical defluffing and acid extraction for 20 min. The acid extraction for seven min. recorded the lowest recovery (10.89 per cent).

4.5.2. Injured seeds (Table 17)

The extracted true seeds exhibited significant differences in the extent of mechanical injury ranging from zero (manual) to five per cent (mechanical). The injury was nil in acid extraction upto the duration of 13 min. and it was the highest (5 per cent) at 20 min. duration.

Table 17. Effect of seed extraction methods on true seed recovery and seed quality parameters in *C. glaucus* cv. CO 1

Seed extraction methods	Seed recovery (%)	Injured seeds (%)	Viability (%)	Germination (%)	Root Length (cm)	Shoot length (cm)	Vigour index
Manual	28.00	-	94	79 (62.78)	5.03	5.23	810
Mechanical	25.63	5.3	94	69 (55.99)	4.83	4.68	653
H_2SO_4 7 min	10.89	-	95	76 (60.46)	4.97	4.77	710
H_2SO_4 10 min	13.80	-	96	73 (58.50)	4.67	5.90	768
H_2SO_4 13 min	18.27	-	95	71 (57.22)	4.76	4.70	670
H_2SO_4 16 min	24.04	2.5	96	72 (57.84)	5.0	4.51	681
H_2SO_4 20 min	25.16	5.0	95	67 (54.94)	5.13	4.44	639
Mean	20.83	1.82	95	72 (58.25)	4.91	4.89	709
$SE\bar{d}$	0.203	0.690	0.082	1.45	0.260	0.299	32.30
CD ($P \leq 0.05$)	0.437	1.480	NS	3.12	NS	0.642	69.28

Figures in the parentheses are arc sine values

4.5.3. Germination (Table 17)

Germination was the highest with manual defluffing (79 per cent) followed by acid extraction for seven min. (76 per cent), while the lowest of 67 per cent was in acid extraction for 20 min.

4.5.4. Shoot length (Table 17)

The longest shoot of 5.90 cm was recorded by seeds extracted with acid for 20 min. and the shortest was in seven min. acid extraction (4.77 cm).

4.5.5. Vigour index (Table 17)

Manual extraction of seeds recorded maximum value (810) followed by acid extraction for 10 min, whereas, 20 min. acid extration recorded the minimum (639).

4.6. Upgrading of fluffs with specific gravity separator

4.6.1. Seed recovery (Table 18)

Seed recovery was maximum in H_1, V_2, A_1 at G_1 whereas minimum in H_2, V_4, A_2, at G_1.

4.6.2. Hundred seed weight (Table 19)

Seeds graded at different levels of horizontal and vertical scales of the deck slope, air flow rate and their interactions showed highly significant values for 100 seed weight.

H_2 (145.2mg) registered more seed weight than H_1, (130.4mg). Among the levels of V, maximum seed weight was obtained with V4 (150.4mg) and minimum in V_1 (126.3mg).

A_2 (165.0mg) recorded the maximum value and A_1 (110.6mg) the minimum.

In HxV, H_2 at V_4 recorded maximum seed weight (156.8mg) and H_1 at V_1 the minimum (118.3mg).

Table 18. Effect of various adjustment levels of specific gravity separator on seed recovery (%) in *C. glaucus* cv. CO 1

Combination			Specific gravity grade class				
H	V	A	G_1	G_2	G_3	G_4	G_5
0	0	3	92.71	2.71	1.54	1.16	1.88
0	0.5	3	94.05	2.66	1.11	0.84	1.34
0	1	3	74.06	10.59	4.77	6.14	4.45
0	1.5	3	87.64	4.70	3.03	2.10	2.52
1	0	3	68.48	25.22	4.43	0.84	1.03
1	0.5	3	67.25	28.29	4.10	0.35	Nil
1	1	3	69.53	22.20	4.66	1.10	1.90
1	1.5	3	62.57	29.45	6.64	0.67	0.67
0	0	4	73.46	11.25	2.41	1.97	10.90
0	0.5	4	78.59	9.49	2.03	1.06	8.83
0	1	4	71.29	16.58	2.87	1.38	7.88
0	1.5	4	40.67	32.49	13.19	2.71	10.94
1	0	4	65.82	19.70	4.56	1.79	8.13
1	0.5	4	64.45	20.41	5.47	0.48	8.00
1	1	4	45.11	32.43	14.74	2.81	4.92
1	1.5	4	12.60	35.85	37.25	4.87	9.43

Not analysed statistically

Table 19. Effect of various adjustment levels of specific gravity separator on hundred seed weight (mg) in *C. glaucus* cv. CO 1

Combination	Specific gravity grade class			Mean
	G_1	G_2	G_3	
H_1V_1	169.0	109.8	76.0	118.3
H_1V_2	166.8	116.2	84.2	122.4
H_1V_3	172.3	129.7	109.2	137.1
H_1V_4	177.3	134.5	120.2	144.0
Mean	171.4	122.5	97.4	130.4
H_2V_1	163.8	133.8	105.5	134.4
H_2V_2	174.0	130.3	122.5	142.3
H_2V_3	175.7	140.8	125.2	147.2
H_2V_4	179.8	155.2	136.5	156.8
Mean	173.3	140.0	122.2	145.2
A_1V_1	162.2	72.3	55.0	96.5
A_1V_2	161.8	79.3	63.8	101.7
A_1V_3	169.7	103.8	86.7	120.1
A_1V_4	175.5	112.3	84.7	124.2
Mean	167.3	92.0	73.5	110.6
A_2V_1	170.7	171.3	126.5	156.2
A_2V_2	179.0	167.2	142.8	163.0
A_2V_3	178.3	166.7	147.7	164.2
A_2V_4	181.7	177.3	171.0	176.7
Mean	177.4	170.6	147.0	165.0
V_1	166.4	121.8	90.8	126.3
V_2	170.4	123.3	103.3	132.3
V_3	174.0	135.3	117.2	142.1
V_4	178.6	144.8	127.8	150.4
Mean	172.4	131.3	109.8	

	H_1A_1	H_1A_2	H_2A_1	H_2A_2
	100.6	160.3	120.6	160.8

	H	V	A	G	HV	HA	HG	VA	VG	AG	HVA	HVG	HAG	VAG	HVAG
SEd	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.001	0.002	0.002	0.002	0.002	0.003
CD ($P \leq 0.05$)	0.001	0.002	0.001	0.002	0.003	0.002	0.002	0.003	0.003	0.002	0.004	0.005	0.003	0.003	0.007

In HxA, H_2 at A_2 registered maximum value (160.8mg) whereas H_1 at A_1, the minimum (100.6 mg).

In HxG, H_2 at G_1 registered the highest seed weight (173.3 mg), which was on par with H_1 at G_1 (171.4 mg) whereas H_1 at G_3 recorded the lowest weight (97.4 mg).

In VxG, V_4 at G_1 recorded maximum weight of seeds (178.6 mg) and V_1 at G_3 recorded the minimum (90.8 mg)

In AxG, A_2 at G_1, registered the highest weight (177.4 mg), whereas A_1 at G_3, the lowest value (73.5 mg).

4.6.3. Ill filled seed percent (Table 20)

Ill filled seed present in the graded seeds varied significantly due to different levels of deck slope, air flow rate and their interaction.

Between H levels, H_2 recorded the minimum of 20.5 per cent, whereas, H_1 the maximum of 34.5 per cent.

Among V levels, V_3 registered the lowest per cent of ill filled seeds (21.63 per cent) whereas, V_1 registered the highest (35.42 per cent).

A_2 recorded less ill filled seeds (13.4 per cent) than A_1 (41.6 per cent).

Among the grades, G_1 recorded the minimum of 2.88 per cent followed by G_2 (12.66 per cent), whereas maximum was in G_3 (25.26 per cent).

Between H and V, minimum ill filled seed was recorded in H_2 at V_2 (18.19 per cent), while maximum was in H_1 at V_1 (48.75 per cent).

In HxA, H_2 at A_2 registered the lowest ill filled seed per cent of 8.43, whereas H_1 at A_1, the highest (50.63 per cent).

Table 20. Effect of various adjustment levels of specific gravity separator on ill filled seed percentage in *C. glaucus* cv. CO 1

Combination	Specific gravity grade class			Mean
	G_1	G_2	G_3	
H_1V_1	13.25	57.00	76.00	48.75
H_1V_2	22.50	42.00	60.25	41.58
H_1V_3	10.75	30.00	29.00	23.25
H_1V_4	14.25	22.50	36.50	24.42
Mean	15.19	37.88	50.44	34.50
H_2V_1	13.00	18.75	34.50	22.08
H_2V_2	10.00	20.76	23.81	18.19
H_2V_3	8.76	13.75	37.50	20.00
H_2V_4	7.00	25.00	33.25	21.75
Mean	9.69	19.57	32.26	20.51
A_1V_1	20.25	62.00	74.50	52.25
A_1V_2	29.00	54.50	68.25	50.58
A_1V_3	19.00	30.75	42.50	30.75
A_1V_4	19.75	34.25	44.50	32.83
Mean	22.00	45.38	57.43	41.60
A_2V_1	6.00	13.75	36.00	18.58
A_2V_2	3.50	8.27	15.81	9.19
A_2V_3	0.51	13.00	24.00	12.50
A_2V_4	1.50	13.25	25.25	13.33
Mean	2.88	12.66	25.26	13.40
V_1	13.13	37.88	55.25	35.42
V_2	16.25	31.38	42.03	29.89
V_3	9.76	21.88	33.25	21.63
V_4	10.63	23.75	34.88	23.08
Mean	12.44	28.72	41.35	

	H_1A_1	H_1A_2	H_2A_1	H_2A_2
	50.63	18.38	32.58	8.43

	H	V	A	G	HV	HA	HG	VA	VG	AG	HVA	HVG	HAG	VAG	HVAG
$\overline{SE}$d	0.69	0.98	0.69	0.84	1.38	0.98	1.20	1.38	1.69	1.20	1.96	2.40	1.70	2.40	3.39
CD ($P \leq 0.05$)	1.39	1.97	1.39	1.70	2.78	1.97	2.41	2.78	3.41	2.41	3.94	4.83	3.41	4.83	6.83

In HxG, minimum ill filled seed was noticed in H_2 at G_1 (9.69 per cent), while maximum in H_1 at G_3 (50.44 per cent).

In VxG, V_3 at G_1 registered minimum ill filled seeds (9.76 per cent), while V_1 at G_3, the maximum (55.25 per cent).

Between A and G, the lowest was recorded in A_2 at G_1 (2.88 per cent), whereas A_1 at G_3 recorded the highest (57.43 per cent).

4.6.4. Germination (Table 21)

Germination was significantly influenced by the slope of the deck, air flow rate and their interaction.

Between H levels, H_2 recorded 46 per cent germination as compared to 44 per cent in H_1.

The highest germination of 47 per cent was observed in V_3 and the lowest in V_4 (44 per cent).

A_2 recorded higher germination (56 per cent) than A_1 (34 per cent).

G_1 registered more germination (63 per cent) than G_2 (45 per cent) and G_3 (28 per cent).

In the interaction of HxV, H_2 at V_1 recorded the highest germination (53 per cent), while H_1 at V_1, the lowest (37 per cent).

In HxA, maximum germination of 63 per cent was recorded in H_1 at A_2, whereas minimum of 26 per cent in H_1 at A_1.

In HxG, H_2 at G_1 recorded maximum germination (64 per cent), while H_2 at G_3 registered the minimum (26 per cent) followed by H_1 at G_3 (30 per cent).

Table 21. Effect of various adjustment levels of specific gravity separator on seed germination (%) in *C. glaucus* cv. CO 1

Combination	Specific gravity grade class			Mean
	G_1	G_2	G_3	
H_1V_1	64 (53.55)	27 (27.51)	19 (19.27)	37 (33.45)
H_1V_2	60 (50.90)	39 (36.56)	32 (28.74)	44 (38.73)
H_1V_3	61 (51.48)	51 (45.65)	37 (36.88)	50 (44.67)
H_1V_4	64 (53.05)	47 (42.82)	32 (34.17)	48 (43.34)
Mean	62 (52.25)	41 (38.14)	30 (29.76)	44 (40.05)
H_2V_1	66 (54.86)	57 (48.81)	36 (37.00)	53 (46.89)
H_2V_2	66 (54.36)	45 (42.24)	27 (30.63)	46 (42.41)
H_2V_3	63 (52.26)	49 (44.65)	24 (29.06)	45 (41.99)
H_2V_4	61 (51.44)	41 (39.62)	18 (24.67)	40 (38.58)
Mean	64 (53.23)	48 (43.83)	26 (30.34)	46 (42.46)
A_1V_1	53 (46.80)	25 (26.01)	17 (17.70)	32 (30.17)
A_1V_2	51 (45.73)	22 (26.80)	8 (14.00)	27 (28.84)
A_1V_3	58 (49.62)	41 (39.80)	20 (26.18)	40 (38.53)
A_1V_4	57 (49.25)	39 (38.36)	22 (27.73)	39 (38.45)
Mean	55 (47.85)	32 (32.74)	17 (21.40)	34 (34.00)
a_2V_1	77 (61.62)	59 (50.31)	39 (38.56)	58 (50.16)
a_2V_2	74 (59.53)	62 (51.99)	51 (45.37)	62 (52.30)
a_2V_3	66 (54.12)	59 (50.50)	41 (39.75)	55 (48.12)
a_2V_4	67 (55.24)	49 (44.08)	29 (31.10)	48 (43.47)
Mean	71 (57.63)	.57 (49.22)	40 (38.70)	56 (48.51)
V_1	65 (54.21)	42 (38.16)	28 (28.13)	45 (40.17)
V_2	63 (52.63)	42 (39.40)	29 (29.68)	45 (40.57)
V_3	62 (51.87)	50 (45.15)	30 (32.97)	47 (43.33)
V_4	62 (52.25)	44 (41.22)	25 (29.43)	44 (40.93)
Mean	63 (52.74)	45 (40.98)	28 (30.05)	

H_1A_1	H_1A_2	H_2A_1	H_2A_2
26	63	43	49
(27.53)	(52.55)	(40.47)	(44.46

	H	V	A	G	HV	HA	HG	VA	VG	AG	HVA	HVG	HAG	VAG	HVAG
SEd	0.266	0.376	0.266	0.325	0.531	0.376	0.460	0.531	0.650	0.460	0.751	0.920	0.650	0.920	1.301
CD ($P \leq 0.05$)	0.534	0.755	0.534	0.654	1.068	0.755	0.925	1.068	1.309	0.925	1.511	1.851	1.309	1.851	2.617

Figures in parentheses are arc sine values

In VxA, the highest germination was registered in V_2 at A_2 (62 per cent), whereas, the lowest was recorded in V_2 at A_1.

Maximum germination was recorded in V_1 at G_1 (65 per cent) and minimum in V_4 at G_3 (25 per cent).

In AxG, A_2 at G_1 recorded maximum germination (71 per cent), while A_1 at G_3, the minimum (17 per cent).

4.6.5. Root length (Table 22)

Root length showed significant differences among the levels of horizontal and vertical scales, air flow rates and their interactions.

H_2 recorded more root length (5.17 cm) than H_1 (5.02 cm).

Among V levels, V_3 registered the longest root (5.32 cm) followed by V_4 (5.28 cm), whereas the shortest root was in V_2 (4.77 cm).

A_2 recorded longer root length of 5.43 cm than A_1 (4.75 cm).

G_1 registered higher root length (5.78 cm) than G_2 (5.22 cm) and G_3 (4.27 cm).

In the interaction between HxV, the lengthiest root (5.73 cm) was recorded in H_2 at V_1, whereas the shortest in H_1 at V_1 (4.26 cm).

In HxA, maximum root length was observed in H_2 at A_2 (5.64 cm) and minimum in H_2 at A_1 (4.69 cm), which was on par with H_1 at A_1 (4.81cm).

In HxG, the highest value was recorded in H_2 at G_1 (5.84 cm) followed by H_1 at G_1 (5.73 cm), whereas the lowest in H_1 at G_3 (4.18cm).

Table 22. Effect of various adjustment levels of specific gravity separator on root length of seedlings (cm) in *C. glaucus* cv. CO 1

Combination	Specific gravity grade class			Mean
	G_1	G_2	G_3	
H_1V_1	5.52	5.10	2.16	4.26
H_1V_2	5.84	4.80	4.02	4.89
H_1V_3	5.83	5.31	5.24	5.46
H_1V_4	5.73	5.37	5.31	5.47
Mean	5.73	5.14	4.18	5.02
H_2V_1	6.14	5.73	5.32	5.73
H_2V_2	5.58	4.78	3.61	4.66
H_2V_3	5.79	5.36	4.41	5.19
H_2V_4	5.84	5.31	4.12	5.09
Mean	5.84	5.30	4.36	5.17
A_1V_1	5.78	5.19	2.04	4.34
A_1V_2	5.59	4.60	3.05	4.41
A_1V_3	5.62	5.20	4.77	5.20
A_1V_4	5.58	5.12	4.50	5.07
Mean	5.64	5.03	3.59	4.75
A_2V_1	5.87	5.64	5.44	5.65
A_2V_2	5.84	4.98	4.59	5.13
A_2V_3	6.00	5.47	4.89	5.45
A_2V_4	6.00	5.55	4.93	5.50
Mean	5.93	5.41	4.96	5.43
V_1	5.83	5.41	3.74	5.0
V_2	5.71	4.79	3.82	4.77
V_3	5.81	5.33	4.83	5.32
V_4	5.79	5.34	4.70	5.28
Mean	5.78	5.22	4.27	

H_1A_1	H_1A_2	H_2A_1	H_2A_2
4.81	5.22	4.69	5.64

	H	V	A	G	HV	HA	HG	VA	VG	AG	HVA	HVG	HAG	VAG	HVAG
SEd	0.04	0.06	0.045	0.05	0.08	0.06	0.07	0.08	0.11	0.07	0.12	0.15	0.11	0.15	0.21
CD ($P \leq 0.05$)	0.08	0.12	0.08	0.10	0.17	0.12	0.15	0.17	0.21	0.15	0.21	0.30	0.22	0.30	0.43

In VxA, the longest root was noticed in V_1 at A_2 (5.65 cm), followed by V_4 at A_1 (5.07 cm), while the shortest was in V_1 at A_1 (4.34 cm) which was on par with V_2 at A_1 (4.41 cm).

In V x G the highest value was recorded in V_1 at G_1 (5.83 cm) followed by V_3 at G_1 (5.81 cm) whereas the lowest was in V_1 at G_3 (3.75 cm).

In AxG, root length was the highest in A_2 at G_1 (5.93 cm) and lowest in A_1 at G_3 (3.59 cm).

4.6.6. Shoot length (Table 23)

Shoot length revealed significant differences among the slopes of deck, air flow rates and their interactions.

Between H levels, H_2 registered longer shoot (5.37 cm) than H_1 (5.10 cm).

Among V levels, V_3 recorded the lengthiest shoot (5.40 cm) which was on par with V_4 (5.38 cm) and at V_2 and V_1, the lowest.

Shoot length of A_2 was higher (5.61 cm) than that of A_1 (4.86 cm).

The lengthiest shoot was observed in G_1 (5.70 cm) and the shortest in G_3 (4.59cm).

In HxV, maximum shoot length was recorded in H_2 at V_1 (5.78 cm) while minimum in H_1 at V_1 (4.36 cm).

In the interaction of HxA, the longest shoot of 5.89cm was observed in H_2 at A_2. H_1 at A_1 recorded the shortest (4.88 cm).

In HxG, the longest shoot was registered in H_2 at G_1 (5.77cm) followed by H_1 at G_1 (5.63 cm) and the lowest in H_1 at G_3 (4.36 cm).

Table 23. Effect of various adjustment levels of specific gravity separator on shoot length of seedlings (cm) in *C. glaucus* cv. CO 1

Combination	Specific gravity grade class			Mean
	G_1	G_2	G_3	
H_1V_1	5.56	5.05	2.46	4.36
H_1V_2	5.93	5.38	4.21	5.17
H_1V_3	5.33	5.43	5.41	5.39
H_1V_4	5.71	5.44	5.37	5.50
Mean	5.63	5.32	4.36	5.11
H_2V_1	6.04	6.01	5.30	5.78
H_2V_2	5.49	5.00	4.55	5.01
H_2V_3	5.77	5.57	4.91	5.41
H_2V_4	5.78	5.47	4.52	5.26
Mean	5.77	5.51	4.82	5.37
A_1V_1	5.49	5.09	2.07	4.21
A_1V_2	5.77	5.33	3.82	4.97
A_1V_3	5.45	5.44	4.94	5.27
A_1V_4	5.55	5.21	4.20	4.99
Mean	5.56	5.27	3.76	4.86
A_2V_1	6.11	5.97	5.70	5.92
A_2V_2	5.65	5.05	4.94	5.21
A_2V_3	5.65	5.56	5.38	5.53
A_2V_4	5.94	5.70	5.69	5.77
Mean	5.84	5.57	5.42	5.61
V_1	5.80	5.53	3.88	5.07
V_2	5.71	5.19	4.38	5.09
V_3	5.55	5.50	5.16	5.40
V_4	5.74	5.45	4.94	5.38
Mean	5.70	5.42	4.59	

H_1A_1	H_1A_2	H_2A_1	H_2A_2
4.88	5.33	4.85	5.89

	H	V	A	G	HV	HA	HG	VA	VG	AG	HVA	HVG	HAG	VAG	HVAG
SEd	0.05	0.08	0.05	0.06	0.11	0.08	0.09	0.11	0.13	0.09	0.16	0.19	0.13	0.19	0.27
CD ($P \leq 0.05$)	0.11	0.15	0.11	0.13	0.22	0.15	0.19	0.22	0.27	0.19	0.32	0.39	0.27	0.38	0.54

In VxA, V_1 and V_4 at A_2 recorded the highest value for shoot length, whereas V_1 at A_1, the lowest (4.21cm).

In VxG, at all V levels, G_1 registered maximum shoot length which was on par with V_1 at G_2, while V_1 at G_3 registered the minimum.

In AxG, the longest shoot was observed in A_2 at G_1 (5.84 cm), while the shortest in A_1 at G_3 (3.76 cm).

4.6.7. Vigour index (Table 24)

Significant variations were observed in vigour index due to horizontal and vertical scales for deck slope, air flow rates and their interactions.

Between H levels, H_2 recorded more vigour index (505) than H_1 (482).

Among V levels, V_3 registered maximum vigour index (517) followed by V_1 (509), while V_2 registered the minimum (471) which was on par with V_4 (476).

Vigour index was more in A_2 (624) than in A_1 (362).

G_1 recorded more vigour index (728) than G_2 (476) and G_3 (276).

In the interaction of HxV, H_2 at V_1 registered maximum vigour index value of 626, and H_1 at V_1, the minimum (391).

In HxA, maximum vigour index was recorded in H_1 at A_2 (668) and minimum in H_1 at A_1 (295).

Between HxG, H_2 at G_1 registered the highest vigour index (743), while H_2 at G_3, the lowest (248).

In VxA, maximum vigour index was recorded in V_1 at A_2 (686), while minimum in V_2 at A_1 (286).

Table 24. Effect of various adjustment levels of specific gravity separator on vigour index values of seedlings in *C. glaucus* cv. CO 1

Combination	Specific gravity grade class			Mean
	G_1	G_2	G_3	
H_1V_1	718	279	177	391
H_1V_2	.706	402	307	472
H_1V_3	701	533	383	539
H_1V_4	723	502	347	524
Mean	712	429	303	482
H_2V_1	809	676	392	626
H_2V_2	728	451	233	470
H_2V_3	724	536	226	495
H_2V_4	713	431	143	429
Mean	743	523	248	505
A_1V_1	599	260	136	332
A_1V_2	580	223	55	286
A_1V_3	661	429	189	427
A_1V_4	637	395	183	405
Mean	619	327	141	362
A_2V_1	928	695	432	686
A_2V_2	854	630	484	656
A_2V_3	764	641	420	608
A_2V_4	799	537	307	548
Mean	836	626	411	624
V_1	764	478	284	509
V_2	717	427	270	471
V_3	713	535	305	517
V_4	718	466	245	476
Mean	728	476	276	

H_1A_1	H_1A_2	H_2A_1	H_2A_2
295	668	429	581

	H	V	A	G	HV	HA	HG	VA	VG	AG	HVA	HVG	HAG	VAG	HVAG
$SE\bar{d}$	5.14	7.27	5.14	6.30	10.29	7.27	8.91	10.29	12.60	8.91	14.55	17.81	12.6	17.82	25.20
CD ($P \leq 0.05$)	10.21	14.44	10.21	12.51	20.43	14.43	17.69	20.43	25.02	17.69	28.89	35.38	25.02	35.38	50.03

In VxG, V_1 at G_1 recorded maximum vigour index of 764 and minimum in V_4 at G_3 (245).

In the interaction of AxG, maximum vigour index was registered in A_2 at G_1 (836), while minimum in A_1 at G_3 (141).

4.7. Dormancy breaking treatments

4.7.1. Fluff

Fluffs exhibited highly significant differences for germination, shoot length and vigour index values due to different dormancy breaking treatments.

4.7.1.1. Germination (Table 25)

Among different treatments, T_7 registered the highest germination of 69 per cent, which was on par with T_6, T_4, T_3 and T_2 and the lowest was registered by T_0 (42 per cent) followed by T_1 (48 per cent).

4.7.1.2. Shoot length (Table 25)

Among different treatments , T_9 registered the highest shoot length of 8.39 cm. The lowest value of 5.22 cm was recorded in T_8 which was on par with T_0, T_1, T_3 and T_5.

4.7.1.3. Vigour index (Table 25)

Vigour index value was the highest in T_9 (766) which was on par with all other treatments except T_0, T_1, T_5 and T_8. To recorded the lowest (433) followed by T_1 and T_8.

4.7.2. Bioassay test

4.7.2.1. Germination (Table 26)

Control seeds (T_1) recorded the highest germination of 74 per cent, while T_2 recorded nil germination.

4.7.2.2. Root length (Table 26)

The longest root was recorded at T_5 (3.03 cm) whereas T_3 recorded the minimum (1.58 cm).

Table 25. Effect of dormancy breaking treatments on seed germination, root and shoot length of seedlings and vigour index of fluffs in *C. glaucus* cv. CO 1

Treatments	Germination (%)	Root length (cm)	Shoot length (cm)	Vigour index
T_0	42 (40.22)	4.46	5.75	433
T_1	48 (43.85)	4.53	5.80	496
T_2	65 (53.78)	4.38	6.25	690
T_3	64 (53.22)	4.61	5.78	667
T_4	63 (52.24)	4.62	5.45	666
T_5	61 (51.37)	4.32	6.18	641
T_6	68 (55.68)	4.64	6.27	742
T_7	69 (55.87)	4.96	6.13	759
T_8	56 (48.46)	4.56	5.22	548
T_9	58 (49.62)	4.79	8.39	766
T_{10}	52 (46.44)	4.55	8.27	705
T_{11}	52 (45.87)	4.57	7.90	690
M	58 (49.90)	4.58	6.45	650
SE $\bar{d}$	2.11	0.189	0.294	50.19
CD ($P \leq 0.05$)	4.28	NS	0.596	101.80

Figures in parentheses are arc sine values

Table 26. Effect of glume extract on seed germination, root and shoot length of seedling and vigour index in *C. glaucus* cv. CO 1

Treatments	Germination (%)	Root length (cm)	Shoot length (cm)	Vigour index
T_1	74 (59.21)	2.83	4.15	517
T_2	0 (0.31)	-	-	-
T_3	18 (25.40)	1.58	2.7	75
T_4	30 (33.27)	2.60	3.35	177
T_5	49 (41.73)	3.03	4.40	360
Mean	34 (35.73)	2.01	2.92	226
$SE\bar{d}$	0.709	0.113	0.121	10.28
CD ($P \leq 0.05$)	1.511	0.241	0.258	21.91

Figures in parentheses are arc sine values

4.7.2.3. Shoot length (Table 26)

Shoot length was maximum at T_5 (4.40 cm) and minimum in T_3 (2.70 cm).

4.7.2.4. Vigour index (Table 26)

T_1 recorded the highest value of 517 and T_3, the lowest (75).

4.7.3. True seeds

Different chemical treatments at different concentrations significantly influenced germination, shoot length and vigour index of true seeds.

4.7.3.1. Germination (Table 27)

Among the treatments, T_5 and T_6 recorded the highest germination of 80 per cent, followed by T_4 (79 per cent) and T_2 (74 per cent), whereas T_{10} recorded the lowest (52 per cent).

4.7.3.2. Shoot length (Table 27)

Irrespective of concentrations, GA treated seeds (T_8, T_9 and T_{10}) registered the longest shoot and T_0, the shortest (3.88 cm) followed by T_1, T_2 and T_3.

4.7.3.3. Vigour index (Table 27)

Maximum vigour index value was recorded in T_6 (619), followed by T_5 (578) and T_4 (568), while the minimum was in T_0 (313) which was on par with T_1 and T_{10}.

4.8. Seed pelleting

4.8.1. Performance of pelleted seeds

Seed pelleting showed significant variations for all the seed quality parameters studied.

4.8.1.1. Germination (Table 28)

Among the treatments, T_7 registered maximum germination of 68 per cent followed by T_5 (67 per cent). T_2 and T_8 recorded the lowest germination of 60 per cent.

Table 27. Effect of dormancy breaking treatments on seed germination, root and shoot length of seedlings and vigour index of true seeds in *C. glaucus* cv. CO 1

Treatments	Germination (%)	Root length (cm)	Shoot length (cm)	Vigour index
T_0	62 (51.96)	2.16	3.88	313
T_1	65 (53.75)	2.29	4.15	354
T_2	74 (59.39)	2.38	4.29	494
T_3	62 (51.96)	2.40	4.11	404
T_4	79 (62.77)	2.56	4.63	568
T_5	80 (63.67)	2.49	4.72	578
T_6	80 (63.51)	2.77	4.98	619
T_7	70 (56.89)	2.50	4.93	519
T_8	64 (53.15)	2.38	5.71	438
T_9	66 (54.42)	2.48	5.38	440
T_{10}	52 (46.15)	2.66	5.85	357
M	69 (56.15)	2.44	4.78	462
SE $\bar{d}$	2.19	0.217	0.339	37.67
CD ($P \leq 0.05$)	4.45	NS	0.691	76.64

Figures in parentheses are arc sine values

4.8.1.2. Root length (Table 28)

T_3 registered the longest root of 4.93 cm, while the lowest was in T_0 (3.83 cm) which was on par with T_8 (4.03 cm) and T_9 (3.95 cm).

4.8.1.3. Shoot length (Table 28)

Pelleted seeds of T_3 produced the longest shoot (6.35 cm) followed by T_4 (5.70 cm). Control (T_0) seeds recorded the lowest (4.53 cm).

4.8.1.4. Vigour index (Table 28)

T_3 registered the highest vigour index of 686 followed by T_4 (651) and T_7 (645) whereas T_0 recorded the lowest (522), which was on par with T_1, T_2, T_8 and T_9.

4.8.2. Field performance of pelleted seeds

4.8.2.1. Field emergence (Table 29)

Among the treatments, T_7 registered maximum emergence of 62 per cent followed by T_5 (61 per cent). Minimum was in T_8 (54 per cent) which was on par with all other treatments including control.

4.8.2.2. Seedling length (Table 29)

T_3 registered the longest shoot of 56.20 cm while the shortest was in T_9 (32.25 cm) which was on par with control (31.75 cm).

4.8.2.3. Fresh weight of seedling (Table 29)

Among the treatments, T_3 recorded maximum fresh weight (10.055g) while minimum was in T_0 (2.868g) which was on par with T_1 (3.188g) and T_9 (3.023g).

4.8.2.4. Dry weight of seedling (Table 29)

The highest dry weight of seedling was observed in T_3 (1.553 g) followed by T_4 (1.442g), whereas the lowest was in T_0 (0.506g) which was on par with T_9 (0.516g) and T_1 (0.522g).

Table 28. Effect of seed pelleting on seed germination, root and shoot length of seedlings and vigour index in *C. glaucus* cv. CO 1

Treatments	Germination (%)	Root length (cm)	Shoot length (cm)	Vigour index
T_0	63 (53.74)	3.83	4.53	522
T_1	60 (50.62)	4.13	5.23	558
T_2	60 (50.48)	4.30	5.13	560
T_3	61 (51.21)	4.93	6.35	686
T_4	65 (53.88)	4.28	5.70	651
T_5	67 (54.65)	4.13	5.13	616
T_6	63 (52.69)	4.40	5.20	608
T_7	68 (55.56)	4.33	5.15	645
T_8	60 (50.62)	4.03	5.28	556
T_9	62 (51.66)	3.95	5.13	559
M	63 (52.52)	4.23	5.28	596
SE$\bar{d}$	1.16	0.157	0.198	24.56
CD ($P \leq 0.05$)	2.37	0.321	0.404	50.15

Figures in parentheses are arc sine values

Table 29. Effect of seed pelleting on field emergence and seedling vigour parameters in *C. glaucus* cv. CO 1

Treatments	Field emergence (%)	Seedlings after 30 days			Vigour index
		Shoot length (cm)	Fresh weight seedling^{-1} (g)	Dry weight seedling^{-1} (g)	
T_0	57 (49.03)	31.75	2.868	0.506	29
T_1	55 (47.87)	35.38	3.188	0.522	30
T_2	54 (47.30)	37.00	5.160	0.826	45
T_3	56 (48.46)	56.20	10.055	1.553	88
T_4	58 (49.61)	49.00	8.356	1.442	83
T_5	61 (51.37)	41.70	3.975	0.613	37
T_6	54 (47.29)	40.75	4.365	0.800	43
T_7	62 (51.96)	41.75	4.491	0.822	51
T_8	54 (47.29)	40.00	4.325	0.786	43
T_9	55 (47.80)	32.25	3.023	0.516	29
M	57.0 (48.81)	40.58	4.981	0.839	48
SE $\overline{d}$	1.56	3.46	0.36	0.07	4.96
CD ($P \leq 0.05$)	3.202	7.09	0.75	0.15	10.19

Figures in parentheses are arc sine values

4.8.2.5. Vigour index (Table 29)

Vigour index was maximum in T_3 (88) followed by T_4 (83) and minimum in T_9 (29) which was on par with T_0 (29), T_1 (30) and T_5 (37).

4.8.3. Storage of pelleted seeds

4.8.3.1. Germination (Table 30)

Among the treatments T_8 recorded the highest germination (80 per cent) which was on par with T_0 (79 per cent) and T_9 (76 per cent). The lowest was in T_2, T_3 and T_4 (70 per cent).

4.8.3.2. Root length (Table 30)

The longest root of 5.0 cm was recorded by T_1, while the shortest was in T_8 (3.84 cm) which was on par with T_6 (4.07 cm), T_3 (4.06 cm) and T_7 (4.15 cm).

4.8.3.3. Shoot length (Table 30)

The lengthiest shoot was observed in T_6 (5.45 cm) and which was on par with all other treatments except T_0, T_1, T_2 and T_3. T_0 recorded the shortest shoot of 4.74 cm which was on par with T_1, T_2 and T_3.

4.8.3.4. Vigour index (Table 30)

Among the treatments, T_9 recorded maximum vigour index (757) value which was on par with T_6, T_8 and T_1. All other treatments were on par with the lowest value of 629 recorded in T_2.

4.9. Storage studies

4.9.1. Fluff storage

Variations in seed moisture, percentage of germination, root and shoot length of seedlings, vigour index and electrical conductivity of seed leachate were significant due to periods of storage, treatments and containers except for the treatmental effects on

Table 30. Effect of seed pelleting on seed germination, root and shoot length of seedlings and vigour index after three months storage in *C. glaucus* cv. CO 1

Treatments	Germination (%)	Root length (cm)	Shoot length (cm)	Vigour index
T_0	79 (62.75)	4.33	4.74	716
T_1	74 (59.36)	5.00	4.83	727
T_2	70 (56.80)	4.08	4.80	629
T_3	70 (56.84)	4.06	4.96	632
T_4	69 (55.99)	4.40	5.01	651
T_5	74 (59.39)	4.27	5.16	701
T_6	75 (60.01)	4.07	5.45	715
T_7	75 (60.21)	4.15	5.04	689
T_8	80 (63.46)	3.84	5.22	724
T_9	76 (60.68)	4.55	5.41	757
M	74 (59.55)	4.28	5.07	694
SE$\bar{d}$	1.45	0.19	0.22	32.51
CD ($P \leq 0.05$)	2.96	0.39	0.44	66.40

Figures in parentheses are arc sine values

germination. Interaction between periods of storage and containers was significant for all parameters except root and shoot length of the seedling and electrical conductivity of seed leachate. Interaction of PxT was significant for shoot length and electrical conductivity only. The PxTxC interaction was non significant for all the parameters except shoot length of seedlings.

4.9.1.1. Moisture content (Table 31)

Seed moisture content increased significantly from 10.2 per cent (P_0) to 10.33 per cent (P_6) and decreased gradually to 10.13 per cent (P_{12}) at the end of the storage period.

Between treatments, T_1 registered lower fluff moisture (10.22 per cent) than T_2 (10.29 per cent).

Between containers, C_2 recorded lower moisture content of 10.23 per cent than C_1 (10.28 per cent).

In PxC, P_{12} at C_1 registered the lowest moisture (10.0 per cent), while P_6 and P_8 at C_1 registered thc highest moisture (10.40 per cent) followed by P_4 ät C_1.

4.9.1.2. Germination (Table 32)

Seed germination gradually increased during storage from 23 per cent (P_0) to 85 per cent (P_{12}).

Between containers, C_1 (57 per cent) recorded higher germination than C_2 (53 per cent).

In the interaction of PxC, P_{12} at C_1 registered maximum germination of 87 per cent while P_0 registered minimum in both containers.

4.9.1.3. Root length (Table 33)

Irrespective of containers and treatments, P_4 registered the longest root (8.30 cm), followed by P_6 and P_2, whereas P_{12} registered the shortest (4.96 cm).

Table 31. Effect of treatments, containers and periods of storage on moisture content of fluff (%) in *C. glaucus* cv. CO 1

Period of storage / treatments	T_1			T_2			C_1	C_2	Grand Mean
	C_1	C_2	M	C_1	C_2	M			
P_0	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2
P_2	10.2	10.2	10.2	10.3	10.2	10.3	10.25	10.0	10.23
P_4	10.3	10.2	10.25	10.4	10.2	10.28	10.33	10.2	10.26
P_6	10.35	10.25	10.30	10.45	10.25	10.35	10.40	10.25	10.33
P_8	10.25	10.24	10.30	10.45	10.25	10.35	10.40	10.25	10.33
P_{10}	10.3	10.25	10.28	10.40	10.25	10.33	10.35	10.25	10.30
P_{12}	9.75	10.25	10.0	10.25	10.25	10.25	10.00	10.25	10.13
M	10.21	10.23	10.22	10.34	10.23	10.29	10.28	10.23	10.07

	P	T	C	PT	TC	PC	PTC
SE $\bar{d}$	0.045	0.024	0.234	0.063	0.034	0.063	0.089
CD ($P \leq 0.05$)	0.092	0.049	NS	0.310	NS	0.130	0.183

Table 32. Effect of treatments, containers and periods of storage on fluff germination (%) in *C. glaucus* cv. CO 1

Period of storage / treatments	T_1			T_2					Grand Mean
	C_1	C_2	M	C_1	C_2	M	C_1	C_2	
P_0	23 (28.28)	23 (28.28)	23 (28.28)	23 (28.28)	23 (28.28)	23 (28.28)	23 (28.28)	23 (28.28)	23 (28.28)
P_2	32 (34.44)	28 (31.93)	30 (33.19)	30 (33.21)	30 (33.18)	30 (33.19)	31 (33.83)	29 (32.56)	30 (33.19)
P_4	44 (41.54)	37 (37.16)	40 (39.35)	48 (43.56)	36 (36.86)	42 (40.21)	46 (42.55)	36 (37.01)	41 (39.78)
P_6	60 (50.49)	44 (41.55)	52 (46.02)	60 (50.47)	53 (46.72)	56 (48.60)	60 (50.48)	49 (44.14)	54 (47.31)
P_8	73 (58.44)	70 (56.49)	71 (57.47)	75 (60.00)	74 (59.38)	75 (56.69)	74 (59.22)	72 (57.94)	73 (58.58)
P_{10}	83 (65.66)	75 (60.07)	79 (62.86)	82 (64.62)	78 (62.02)	80 (63.32)	82 (65.14)	77 (61.05)	79 (63.09)
P_{12}	86 (67.64)	85 (66.88)	85 (67.26)	88 (69.30)	83 (65.66)	85 (67.48)	87 (68.47)	84 (66.27)	85 (67.37)
M	57 (49.50)	51 (46.05)	54 (47.78)	58 (49.92)	54 (47.44)	56 (48.68)	57 (49.71)	53 (46.25)	

	P	T	C	PT	TC	PC	PTC
$SE\bar{d}$	1.049	0.560	0.560	1.483	0.793	1.483	2.098
CD ($P \leq 0.05$)	2.149	NS	1.484	NS	NS	3.039	NS

Figure in parentheses are arc sine values

Table 33. Effect of treatments, containers and periods of storage on root and shoot length of the seedlings of fluffs in *C. glaucus* cv. CO 1

Period of storage / treatments	Root length (cm)							Shoot length (cm)						
	T_1			T_2			Grand Mean	T_1			T_2			Grand Mean
	C_1	C_2	M	C_1	C_2	M		C_1	C_2	M	C_1	C_2	M	
P_0	7.2	7.2	7.2	7.2	7.2	7.2	7.2	4.69	4.69	4.69	4.69	4.69	4.69	4.69
P_2	7.75	8.0	7.87	7.98	8.34	8.16	8.01	4.74	5.34	5.04	5.22	5.44	5.33	5.18
P_4	7.40	8.47	7.93	8.74	8.61	8.67	8.30	5.67	7.14	6.40	6.21	5.71	5.96	6.18
P_6	7.55	7.83	7.69	8.53	8.50	8.51	8.10	5.60	5.65	5.62	6.07	6.17	6.13	5.88
P_8	5.79	6.04	5.91	6.09	6.28	6.18	6.05	5.76	5.96	5.86	5.58	6.83	6.29	6.03
P_{10}	5.25	5.43	5.34	5.47	5.46	5.46	5.40	5.22	5.73	5.47	5.46	5.96	5.71	5.56
P_{12}	4.29	5.18	4.73	4.86	5.50	5.18	4.96	5.62	5.96	5.86	5.8	8.3	6.03	5.72
M	6.46	6.87	6.67	6.98	7.12	7.05		5.33	5.65	5.49	5.59	5.87	5.73	

C1 : 6.72 C2 : 7.00 C1 : 5.46 C2 : 5.76

	P	T	C	PT	TC	PC	PTC	P	T	C	PT	TC	PC	PTC
SEd	0.193	0.103	0.103	0.274	0.146	0.274	0.387	0.172	0.092	0.091	0.243	0.130	0.243	0.344
CD ($P \leq 0.05$)	0.397	0.212	0.212	NS	NS	NS	NS	0.352	0.188	0.188	0.499	NS	NS	0.705

Between treatments, T_2 (7.05 cm) recorded lengthier root than T_1 (6.67 cm). Higher root length was recorded in C_2 (7.0 cm) than in C_1 (6.72 cm).

4.9.1.4. Shoot length (Table 33)

Shoot length of the seedlings increased when the period of storage advanced and reached the maximum from 4.69 cm (P_0) to 6.18 cm at P_4, which declined thereafter to 5.72 cm at P_{12}.

Between the treatments and containers, T_2 in C_2 recorded the longest shoot and T_1 in C_1, the shortest.

In PxT, maximum shoot length was recorded in P_4 at T_1 (6.40 cm) followed by P_4, P_6 and P_8 at T_2, while minimum was in P_0 at T_1 & T_2 (4.69 cm).

4.9.1.5. Vigour index (Table 34)

Between treatments, T_1 (644) recorded higher values than T_2 (631).

In PxC, irrespective of containers, P_{12} at C_2 registered maximum value of 983 followed by P_{10} and P_8.

4.9.1.6. Electrical conductivity (Table 35)

Electrical conductivity of seed leachate was the highest at the initial period of storage which gradually decreased to 0.096 at P_6 and P_8 and increased thereafter when period of storage advanced.

Between containers, C_2 (0.106) recorded lesser value than C_1 (0.110).

In PxT, P_6 and P_8 at T_1 recorded minimum while P_0 and P_2, the maximum.

4.9.2. Scarified fluff storage

Significant variations were observed in seed moisture content, germination, root length and shoot length of seedlings, vigour index values and electrical conductivity of seed leachate due to periods of storage, treatments and containers except the container

Table 34. Effect of treatments, containers and periods of storage of fluffs on vigour index in *C. glaucus* cv. CO 1

Period of storage / treatments	T_1			T_2			C_1	C_2	Grand Mean
	C_1	C_2	M	C_1	C_2	M			
P_0	270	270	270	270	270	270	270	270	270
P_2	400	375	388	396	414	405	398	394	396
P_4	579	570	574	710	516	613	644	542	593
P_6	785	593	689	869	778	823	827	685	756
P_8	840	834	837	876	972	924	858	903	880
P_{10}	870	836	853	889	892	890	880	864	872
P_{12}	860	942	900	914	1024	969	887	983	935
M	657	631	644	703	695	631	680	663	

	P	T	C	PT	TC	PC	PTC
$SE\bar{d}$	30.40	16.25	16.25	42.99	22.98	42.99	60.80
CD ($P \leq 0.05$)	62.27	33.29	NS	NS	NS	88.06	NS

Table 35. Effect of treatments, containers and periods of storage on electrical conductivity of fluffs (dSm^{-1}) in *C. glaucus* cv. CO 1

Period of storage / treatments	T1			T2			C_1	C_2	Grand Mean
	C_1	C_2	M	C_1	C_2	M			
P_0	0.117	0.117	0.117	0.117	0.117	0.117	0.117	0.117	0.117
P_2	0.117	0.114	0.115	0.115	0.113	0.114	0.116	0.114	0.114
P_4	0.114	0.105	0.109	0.117	0.116	0.116	0116	0.111	0.113
P_6	0.091	0.090	0.090	0.102	0.101	0.101	0.097	0.096	0.096
P_8	0.100	0.091	0.096	0.104	0.090	0.097	0.103	0.091	0.096
P_{10}	0.110	0.109	0.109	0.110	0.100	0.105	0.110	0.105	0.107
P_{12}	0.114	0.115	0.114	0.112	0.105	0.108	0.113	0.110	0.111
M	0.109	0.106	0.107	0.111	0.106	0.108	0.110	0.106	

	P	T	C	PT	TC	PC	PTC
$SE\bar{d}$	0.002	0.001	0.001	0.003	0.001	0.003	0.004
CD ($P \leq 0.05$)	0.004	NS	0.002	0.006	NS	NS	NS

effect on seed moisture and vigour index values. The interaction effect of period of storage and container was significant for all the parameters except root length of the seedlings. Other interactions P x T, T x C and P x T x C were non significant for all the parameters studied except seed moisture content.

4.9.2.1. Moisture content (Table 36)

Seed moisture content increased from 10.3 per cent (P_0) to 10.51 per cent at P_8 which decreased thereafter to 10.09 per cent at P_{12}.

Between treatments T_1 recorded lower moisture (10.32 per cent) than T_2 (10.39 per cent).

In the interaction of PxC, C_1 at P_{12} registered the lowest value of 9.78 per cent whereas the highest moisture was in C_1 at P_8 (10.63 per cent) followed by P_4 and P_6 at C_1.

In P x T, P_2 at T_1 recorded the lowest moisture of 10.2 per cent and it was highest in P_8 at T_2 (10.65 per cent).

4.9.2.2. Germination (Table 37)

Germination of the scarified seeds increased gradually with the advancement in storage from 44 per cent at P_0 to 85 per cent at P_{12}, irrespective of containers and treatments.

Between the containers, C_1 registered higher germination (72 per cent) than C_2 (68 per cent).

In PxC, C_1 at P_8 registered maximum germination of 88 per cent, while the minimum was at P_0 (44 per cent), in both containers.

4.9.2.3. Root length (Table 38)

The longest root was recorded in P_6 (8.26 cm), followed by P_4, which decreased gradually to 4.34 cm at P_{12}.

Table 36. Effect of treatments, containers and periods of storage on the moisture content of scarified fluffs (%) in *C. glaucus* cv. CO 1

Period of storage / treatments	T_1			T_2			C_1	C_2	Grand Mean
	C_1	C_2	M	C_1	C_2	M			
P_0	10.3	10.3	10.3	10.3	10.30	10.30	10.3	10.3	10.3
P_2	10.1	10.3	10.2	10.5	10.30	10.40	10.3	10.2	10.3
P_4	10.4	10.3	10.35	10.6	10.30	10.45	10.5	10.15	10.40
P_6	10.45	10.3	10.38	10.75	10.40	10.58	10.60	10.38	10.48
P_8	10.45	10.35	10.40	10.80	10.45	10.65	10.63	10.40	10.51
P_{10}	10.30	10.35	10.33	10.50	10.40	10.45	10.40	10.38	10.39
P_{12}	10.20	10.35	10.28	9.35	10.45	9.90	9.78	10.40	10.09
M	10.31	10.32	10.32	10.40	10.37	10.39	10.36	10.35	

	P	T	C	PT	TC	PC	PTC
SE $\overline{d}$	0.045	0.024	0.024	0.063	0.034	0.063	0.089
CD ($P \leq 0.05$)	0.092	0.049	NS	0.130	NS	0.130	0.183

Table 37. Effect of treatments, containers and periods of storage on scarified fluff germination (%) in *C. glaucus* cv. CO 1

Period of storage / treatments	T_1			T_2			C_i	C_2	Grand Mean
	C_1	C_2	M	C_1	C_2	M			
P_0	44 (41.55)	44 (41.55)	44 (41.55)	44 (41.55)	44 (41.55)	44 (41.55)	44 (41.55)	44 (41.55)	44 (41.55)
P_2	58 (49.62)	48 (43.85)	53 (46.74)	56 (48.45)	49 (44.43)	53 (46.44)	57 (49.04)	49 (44.14)	53 (46.58)
P_4	70 (56.84)	66 (54.06)	68 (55.45)	68 (55.57)	64 (52.84)	66 (54.21)	69 (56.21)	65 (53.45)	67 (54.83)
P_6	80 (63.46)	70 (56.87)	75 (60.16)	77 (61.36)	73 (58.40)	75 (59.88)	79 (62.41)	71 (57.63)	75 (60.02)
P_8	87 (68.92)	77 (61.35)	82 (65.14)	88 (69.75)	81 (63.80)	84 (66.77)	88 (69.34)	79 (62.57)	83 (65.96)
P_{10}	85 (67.22)	82 (64.91)	84 (66.06)	86 (68.14)	82 (64.97)	84 (66.56)	86 (67.68)	82 (64.94)	84 (66.31)
P_{12}	85 (67.50)	85 (67.23)	85 (67.36)	85 (67.22)	86 (67.62)	85 (67.42)	85 (67.36)	85 (67.42)	85 (67.39)
M	73 (59.30)	67 (55.69)	70 (57.50)	72 (58.86)	68 (56.23)	70 (57.55)	72 (59.08)	68 (55.96)	

	P	T	C	PT	TC	PC	PTC
$SE\bar{d}$	1.14	0.61	0.61	1.61	0.86	1.61	2.28
CD ($P \leq 0.05$)	2.34	NS	1.253	NS	NS	3.317	NS

Figure in parentheses are arc sine values

Between the treatments, lengthier root was recorded by T_2 (6.83 cm) than T_1 (6.53 cm).

Between the containers, C_2 registered higher root length (6.93 cm) than C_1 (6.43 cm).

4.9.2.4. Shoot length (Table 38)

Shoot length of the seedling was maximum at P_4 (6.69 cm), which gradually decreased to 5.87 cm at P_{12}.

Between the containers, T_2 registered lengthier shoot than T_1.

Between treatments lengthier shoot was recorded in T_2 (6.31 cm) than T_1 (6.07 cm).

In PxC, P_4 at C_1 recorded the longest shoot of 6.96 cm, while P_{12} at C_1 recorded the shortest (5.46 cm).

4.9.2.5. Vigour index (Table 39)

Among periods of storage, the highest vigour index values were recorded at P_6 (1110) and P_8 (1062) while the lowest was at P_0 (562).

Between treatments, T_2 recorded higher vigour index (915) than T_1 (871).

Between the containers and periods of storage, P_6 at C_1, (1168) registered maximum vigour index, whereas P_0 registered the minimum (562), in both the containers.

4.9.2.6. Electrical conductivity (Table 40)

Mean electrical conductivity was the highest at P_0 (0.106 dSm^{-1}) which decreased to 0.073 dSm^{-1} at P_2, then increased gradually and reached 0.093 dSm^{-1} at P_{12}.

Between the treatments, T_2 (0.083 dSm^{-1}) recorded lesser electrical conductivity than T_1 (0.086 dSm^{-1}).

Between the containers, C_2 (0.080 dSm^{-1}) registered lower value than C_1 (0.089 dSm^{-1}).

Table 38. Effect of treatments, containers and periods of storage on root and shoot length of seedlings of scarified fluffs in *C. glaucus* cv. CO 1

Period of storage / treatments	Root length (cm)							Shoot length (cm)						
	T_1			T_2			Grand mean	T_1			T_2			Grand Mean
	C_1	C_2	M	C_1	C_2	M		C_1	C_2	M	C_1	C_2	M	
P_0	6.95	6.95	6.95	6.95	6.95	6.95	6.95	5.80	5.80	5.80	5.80	5.80	5.80	5.80
P_2	7.30	7.65	7.48	7.51	8.43	7.97	7.72	5.18	6.16	5.67	5.38	6.34	5.86	5.76
P_4	7.50	8.28	7.89	8.00	8.46	8.23	8.06	6.85	6.34	6.59	6.96	6.63	6.79	6.69
P_6	7.90	8.00	7.95	8.55	8.60	8.58	8.26	6.36	6.29	6.32	6.98	6.62	6.80	6.56
P_8	6.03	6.32	6.17	6.30	6.72	6.51	6.34	5.93	6.68	6.30	6.80	6.39	6.60	6.20
P_{10}	4.50	5.64	5.07	4.47	5.70	5.08	5.08	5.71	6.30	6.0	6.17	6.62	6.39	6.20
P_{12}	3.87	4.54	4.21	4.23	4.72	4.48	4.34	5.34	6.29	5.82	5.59	6.26	5.92	5.87
M	6.29	6.77	6.53	6.57	7.08	6.83	6.68	5.88	6.26	6.07	6.24	6.38	6.31	

	Root length							Shoot length						
	C1 : 6.43	C2 : 6.93						C1 : 6.06	C2 : 6.32					
	P	T	C	PT	TC	PC	PTC	P	T	C	PT	TC	PC	PTC
$SE\bar{d}$	0.203	0.108	0.108	0.287	0.153	0.287	0.405	0.200	0.107	0.107	0.283	0.151	0.283	0.400
CD ($P \leq 0.05$)	0.415	0.221	0.221	NS	NS	NS	NS	0.410	0.219	0.219	NS	NS	0.580	NS

Table 39. Effect of treatments, containers and periods of storage on vigour index values of scarified fluffs in *C. glaucus* cv. CO 1

Period of storage / Treatments	T1			T2			C_1	C_2	Grand Mean
	C_1	C_2	M	C_1	C_2	M			
P_0	562	562	562	562	562	562	562	562	562
P_2	724	662	693	788	724	756	756	693	725
P_4	1002	957	979	1018	959	988	1010	957	984
P_6	1141	1001	1071	1190	1104	1150	1168	1052	1110
P_8	1040	1002	1021	1152	1055	1103	1095	1028	1062
P_{10}	868	979	923	913	1009	961	890	994	942
P_{12}	783	921	852	835	939	886	809	930	869
M	874	869	871	923	907	915	899	888	

	P	T	C	PT	TC	PC	PTC
SEd	28.30	15.13	15.13	40.02	21.39	40.02	56.60
CD ($P \leq 0.05$)	57.97	30.98	NS	NS	NS	81.98	NS

Table 40. Effect of treatments, containers and periods of storage on the electrical conductivity of scarified fluffs (dSm^{-1}) in *C. glaucus* cv. CO 1

Period of storage / treatments	T1			T2			C_1	C_2	Grand Mean
	C_1	C_2	M	C_1	C_2	M			
P_0	0.106	0.106	0.106	0.106	0.106	0.106	0.106	0.106	0.106
P_2	0.081	0.078	0.079	0.068	0.065	0.066	0.074	0.072	0.073
P_4	0.080	0.069	0.074	0.083	0.065	0.074	0.081	0.067	0.074
P_6	0.080	0.072	0.076	0.086	0.066	0.076	0.083	0.069	0.076
P_8	0.088	0.079	0.083	0.085	0.072	0.079	0.086	0.076	0.081
P_{10}	0.093	0.089	0.091	0.091	0.086	0.089	0.092	0.088	0.090
P_{12}	0.099	0.091	0.095	0.099	0.083	0.091	0.099	0.087	0.093
M	0.089	0.083	0.086	0.089	0.078	0.083	0.089	0.080	

	P	T	C	PT	TC	PC	PTC
$SE\bar{d}$	0.002	0.001	0.001	0.003	0.002	0.003	0.004
CD ($P \leq 0.05$)	0.005	0.002	0.002	NS	NS	0.007	NS

In the interaction of PxC, in both the containers, P_0 registered the highest electrical conductivity (0.106 dSm^{-1}). It was lowest in P_4 at C_2 (0.067 dSm^{-1}).

4.9.3. True seed storage

4.9.3.1. Moisture content (Table 41)

Moisture content was significantly influenced by periods of storage, treatments, containers and the interaction of PxC.

Moisture content increased from 10.05 per cent (P_0) to 10.50 per cent at P_6 and P_8 which decreased to 10.24 per cent at P_{12}.

Between the treatments, T_1 (10.33 per cent) recorded lower moisture than T_2 (10.40 per cent).

Between the containers, C_2 (10.17 per cent) registered lesser moisture than C_1 (10.56 per cent).

In P x C, P_0 at C_1 and C_2 recorded the lowest moisture content, while P_8 and P_{10} at C_1 recorded the highest.

4.9.3.2. Germination (Table 42)

Percentage germination was significantly influenced by periods of storage, treatments, containers and their interactions.

Germination increased from 59 per cent to 79 per cent at P_2 which declined thereafter to 10 per cent at P_{12}.

Between treatments, T_2 (48 per cent) recorded higher germination than T_1 (40 per cent).

Between containers, C_2 was better than C_1.

Table 41. Effect of treatments, containers and periods of storage on moisture content of true seeds (%) in *C. glaucus* cv. CO 1

Period of storage / treatments	T1			T2			C_1	C_2	Grand Mean
	C_1	C_2	M	C_1	C_2	M			
P_0	10.05	10.05	10.05	10.05	10.05	10.05	10.05	10.05	10.05
P_2	10.35	10.10	10.23	10.40	10.10	10.25	10.38	10.10	10.24
P_4	10.70	10.15	10.43	10.85	10.20	10.53	10.78	10.18	10.48
P_6	10.70	10.20	10.45	10.85	10.25	10.55	10.78	10.23	10.50
P_8	10.75	10.20	10.48	10.90	10.20	10.55	10.83	10.20	10.50
P_{10}	10.70	10.20	10.45	10.95	10.20	1058	1083	10.20	10.51
P_{12}	10.02	10.20	10.21	10.30	10.25	10.28	10.26	10.23	10.24
M	10.50	10.16	10.33	10.61	10.18	10.40	10.56	10.17	

	P	T	C	PT	TC	PC	PTC
SE$\overline{d}$	0.032	0.17	0.017	0.045	0.024	0.046	0.064
CD ($P \leq 0.05$)	0.066	0.035	0.035	NS	0.050	0.093	NS

Table 42. Effect of treatments, containers and periods of storage on true seed germination (%) in *C. glaucus* cv. CO 1

Period of storage / treatments	T1			T2			C_1	C_2	Grand Mean
	C_1	C_2	M	C_1	C_2	M			
P_0	58 (49.61)	58 (49.61)	58 (49.61)	60 (50.77)	60 (50.77)	60 (50.77)	59 (50.19)	59 (50.18)	59 (50.19)
P_2	71 (57.45)	81 (64.18)	76 (60.80)	82 (64.93)	82 (64.93)	82 (64.93)	77 (61.18)	82 (64.55)	79 (62.87)
P_4	53 (46.72)	65 (53.73)	59 (50.23)	60 (50.77)	71 (57.42)	66 (54.98v	57 (48.75)	68 (55.58)	62 (52.16)
P_6	27 (31.30)	49 (44.43)	38 (37.87)	41 (39.82)	63 (52.54)	52 (46.18)	34 (35.56)	56 (48.48)	45 (42.02)
P_8	17 (24.27)	32 (34.44)	25 (29.36)	26 (3.64)	44 (41.56)	35 (36.10)	22 (27.46)	38 (38.00)	30 (32.73)
P_{10}	8 (16.43)	22 (27.95)	15 (22.19)	18 (25.07)	38 (38.05)	28 (31.56)	13 (20.75)	30 (33.00)	22 (26.88)
P_{12}	0 (0.383)	14 (21.92)	7 (11.15)	5 (12.86)	21 (27.27)	13 (20.66)	3 (6.62)	18 (24.60)	10 (15.61)
M	33 (32.31)	46 (42.32)	40 (37.32)	42 (39.27)	54 (47.51)	48 (43.39)	38 (35.79)	50 (44.91)	

	P	T	C	PT	TC	PC	PTC
SE $\bar{d}$	0.781	0.418	0.418	1.105	0.591	1.051	1.563
CD ($P \leq 0.05$)	1.601	0.856	0.856	2.264	1.210	2.264	3.201

In the interaction of PxT, P_2 at T_2 registered maximum germination of 82 per cent, while P_{12} at T_1 registered the minimum (7 per cent).

In TxC, the highest germination was registered by T_2 at C_2 (54 per cent), whereas the lowest was in T_1 at C_1 (33 per cent).

In PxC, P_2 at C_2 recorded maximum germination (82 per cent), whereas P_{12} at C_1, the minimum (3 per cent).

4.9.3.3. Root length (Table 43)

Significant differences were observed due to periods of storage, treatments, containers and the interaction of PxC.

Root length decreased from P_0 (8.19 cm) to P_{12} (1.71 cm).

Lengthier root was registered in T_2 (5.42 cm) than in T_1 (4.85 cm).

Between containers, C_2 (5.54 cm) recorded more root length than C_1 (4.75 cm).

In PxC, in both the containers, P_0 recorded the longest root whereas the shortest by P_{12} at C_1 (0.61 cm).

4.9.3.4. Shoot length (Table 44)

Shoot length was influenced by periods of storage, treatments, containers and the interactions of PxT and PxC.

Shoot length was maximum in P_0 (6.40 cm) while it was minimum in P_{12} (2.01 cm).

T_2 recorded more shoot length of 4.85 cm than T_1 (4.33 cm).

Between containers, C_2 (4.96 cm) registered lengtheir shoot than C_1 (4.22 cm).

In the interaction of PxT, P_0 at T_2 recorded maximum shoot length (6.53 cm) followed by P_2 at T_1 while, P_{12} at T_1 recorded the lowest (1.32 cm).

Table 43. Effect of treatments, containers and periods of storage on root length of seedlings of true seeds (cm) in *C. glaucus* cv. CO 1

Period of storage / treatments	T1			T2			C_1	C_2	Grand Mean
	C_1	C_2	M	C_1	C_2	M			
P_0	8.11	8.11	8.11	8.27	8.27	8.27	8.19	8.19	8.19
P_2	7.62	7.68	7.65	8.18	8.07	8.13	7.90	7.88	7.89
P_4	7.43	7.58	7.51	7.64	7.93	7.78	7.54	7.75	7.64
P_6	3.45	4.65	4.05	4.26	5.22	4.74	3.86	4.94	4.40
P_8	2.21	3.34	2.78	3.10	4.05	3.58	2.66	3.70	3.18
P_{10}	1.93	3.16	2.54	2.88	3.83	3.36	2.40	3.50	2.95
P_{12}	0.00	2.68	1.34	1.22	2.95	2.08	0.61	2.81	1.71
M	4.39	5.31	4.85	5.08	5.76	5.42	4.75	5.54	

	P	T	C	PT	TC	PC	PTC
$SE\bar{d}$	0.163	0.087	0.087	0.231	0.123	0.023	0.326
CD ($P \leq 0.05$)	0.334	0.179	0.179	NS	NS	0.472	NS

Table 44. Effect of treatments, containers and periods of storage on shoot length of seedlings in true seeds (cm) in *C. glaucus* cv. CO1

Period of storage / treatments	T1			T2			C_1	C_2	Grand Mean
	C_1	C_2	M	C_1	C_2	M			
P_0	6.26	6.26	6.26	6.53	6.53	6.53	6.40	6.40	6.40
P_2	5.50	5.80	5.65	6.08	6.11	6.09	5.79	5.96	5.87
P_4	5.39	5.57	5.48	5.33	5.76	5.54	5.36	5.66	5.51
P_6	4.49	4.73	4.61	4.72	5.20	4.96	4.60	4.97	4.78
P_8	3.18	4.44	3.81	3.80	4.78	4.29	3.49	4.61	4.05
P_{10}	2.45	3.95	3.20	3.06	4.61	3.83	2.76	4.28	3.52
P_{12}	0.00	2.65	1.32	2.34	3.05	2.70	1.17	2.85	2.01
M	3.89	4.77	4.33	4.55	5.15	4.85	4.22	4.96	

	P	T	C	PT	TC	PC	PTC
SE $\bar{d}$	0.154	0.082	0.082	0.217	0.217	0.116	0.307
CD ($P \leq 0.05$)	0.315	0.168	0.168	0.445	0.445	NS	NS

In P x C, in both the containers, P_0 registered maximum shoot length of 6.40 cm while it was minimum in P_{12} at C_1 (1.17 cm).

4.9.3.5. Vigour index (Table 45)

Vigour index varied significantly due to period of storage, treatments, containers and the interactions of PxT and PxC.

Vigour index declined from 1089 at P_2 to 55 at P_{12}. T_2 recorded more vigour index value than T_1. Between containers, C_2 (588) registered higher vigour index than C_1 (449).

In PxT, maximum vigour index was recorded by P_2 at T_2 (1166) and minimum was by P_{12} at T_1 and T_2.

In the interaction of PxC, P_2 at C_2 registered the highest vigour index value of 1128, while P_{12} at C_1, the lowest (9).

4.9.3.6. Electrical conductivity (Table 46)

Electrical conductivity of seed leachate varied significantly due to periods of storage, treatments, containers and their interactions.

Mean electrical conductivity increased from P_0 (0.033 dSm^{-1}) to P_{12} (0.064 dSm^{-1}).

Between treatments, T_2 (0.040 dSm^{-1}) recorded lower values than T_1 (0.047 dSm^{-1}).

C_2 registered lower value of 0.040 dSm^{-1} than C_1 (0.046 dSm^{-1}).

In PxT, P_2 at T_2 recorded the lowest value while P_{12} at T_1 the highest.

In the interaction between TxC, minimum value was registered in T_2 at C_2 (0.037 dSm^{-1}) and maximum in T_1 at C_1 (0.050 dSm^{-1}).

Between PxC, the lowest value was recorded in P_2 at C_2 (0.030 dSm^{-1}), while the highest in P_{12} at C_1 (0.067 dSm^{-1}).

Table 45. Effect of treatments, containers and periods of storage on vigour index of true seeds in *C. glaucus* cv. CO 1

Period of storage / treatments	T1			T2					Grand Mean
	C_1	C_2	M	C_1	C_2	M	C_1	C_2	
P_0	833	833	833	888	888	888	861	861	861
P_2	932	1092	1012	1168	1163	1166	1050	1128	1089
P_4	680	854	767	777	972	875	729	913	821
P_6	214	460	337	368	656	512	291	558	425
P_8	93	248	170	180	389	284	136	318	227
P_{10}	35	156	96	107	321	214	71	238	155
P_{12}	0	75	38	19	126	72	9	101	55
M	398	531	465	501	645	573	449	588	

	P	T	C	PT	TC	PC	PTC
SE$\overline{d}$	15.20	8.12	8.12	21.49	21.49	11.49	30.39
CD ($P \leq 0.05$)	31.13	16.64	16.64	44.02	44.20	NS	62.25

Table 46. Effect of treatments, containers and periods of storage on electrical conductivity of true seeds leachate (dSm^{-1}) in *C. glaucus* cv. CO 1

Period of storage / treatments	T1			T2					Grand Mean
	C_1	C_2	M	C_1	C_2	M	C_1	C_2	
P_0	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033
P_2	0.038	0.032	0.035	0.030	0.028	0.029	0.034	0.030	0.032
P_4	0.043	0.039	0.041	0.036	0.033	0.034	0.039	0.036	0.037
P_6	0.046	0.040	0.043	0.040	0.033	0.037	0.043	0.037	0.040
P_8	0.050	0.040	0.045	0.042	0.039	0.040	0.046	0.039	0.043
P_{10}	0.067	0.050	0.059	0.054	0.044	0.049	0.061	0.047	0.054
P_{12}	0.073	0.070	0.071	0.060	0.054	0.057	0.067	0.062	0.064
M	0.050	0.043	0.047	0.042	0.037	0.040	0.046	0.040	

	P	T	C	PT	TC	PC	PTC
$SE\bar{d}$	0.0008	0.0004	0.0004	0.0001	0.0006	0.0001	0.0017
CD ($P \leq 0.05$)	0.002	0.009	0.009	0.002	0.001	0.002	0.003

DISCUSSION

CHAPTER V

DISCUSSION

5.1. Influence of dates of sowing and cutting treatments on seed yield and quality

Seed production has special problems in forage crops. It may be necessary to manage the crop for dual purposes. Several investigations have shown that grazing or clipping of forage stands can provide in addition to seeds, high quality forage and at the same time can reduce lodging. However, frequent clipping may decrease subsequent seed yields. The effects obtained varied with soil and climatic conditions (Jacqueline *et al.*, 1984; Parihar and Shankar, 1997), nitrogen fertilization (Singh *et al.*, 1993; Singh *et al.*, 1998) and with the date of application of clipping treatments (Singh *et al.*, 1985; Joshi *et al.*, 1994).

In *Andropogan gayanus*, Andrade and Thomas (1981) found that removal of forage during the first half of the growing season reduced the height of the plant and improved seed production. However, defoliation may not always increase seed production. In pearl millet used for dual purposes, Scheffer *et al.* (1985) found a linear decrease in seed yield with increased number of cuts. It was primarily due to a reduction in the seed yield parameters. In some other species, defoliation could promote vegetative expansion of auxillary buds particularly in forage legume, which might result in greater inflorescence density (Humphreys and Riveros, 1986). However, increased tillering is not always allied with greater inflorescence density. Mishra and Chatterjee (1968) found that repeated cutting stimulated tillering in *Pennisetum polystachyon* and *Andropogan gayanus* but decreased tiller fertility and seed production.

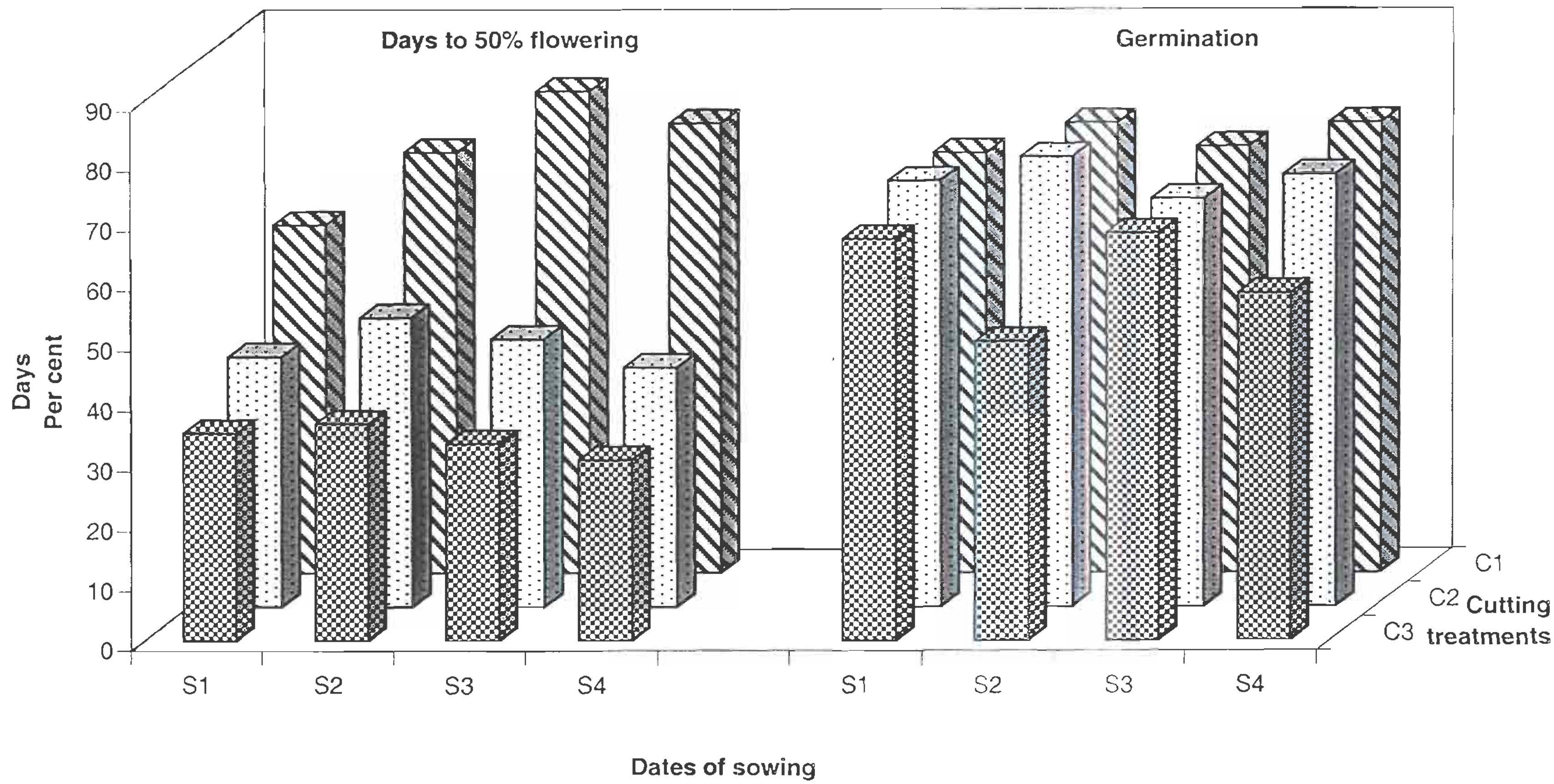
In the present study, plants received one cut for forage had plant height equal to that of plants received no cut but plants received two cuts or more recorded reduced plant height. Plants which received monsoon rain during vegetative growth period recorded more plant height. The plants for which vegetative growth coincided with summer recorded lesser plant higher probably due to high temperature. The results were in agreement with those of Chatterjee and Das (1989) and Singh *et al.* (1993).

The days required for the plants to bloom varied with the seasons and cutting treatments. Plants received two cuts reached flowering very early compared to plants with a single cut for fodder. This might be due to age of the crop. Plants flower more readily with increasing age (Tompsett, 1976). Plants sown during July 28th and November 6th, for which the vegetative phase coincided with monsoon period (August – November) bloomed late compared to other dates of sowing (Fig. 1). This might be due to the prevailing weather with higher relative humidity coupled with low sunshine hours which might have prolonged the vegetative phase of the crop.

Cutting treatments had stimulatory effect on tillering, thus producing more number of tillers in crops given with one cut for fodder before seed production. According to Deo and Rai (1975) and Taneja *et al.* (1981), tiller production was not affected much when the oats crop was cut once for fodder. In *Stylosanthes*, Khara *et al.* (1990) revealed that when the crop was provided with sufficient time for regeneration cutting did not impair seed production. Rainy season if coincided with vegetative phase also had its positive influence on tillering. Similar observations were recorded by Ramaswamy *et al.* (1981) in *Cenchrus ciliaris*, in which more number of total and productive tillers was observed during September followed by May. But in the present study fertile tiller production was affected when crop was cut twice for fodder even during the monsoon months probably due to repeated disturbances, which might have caused loss of photosynthetic material during the vegetative phase.

The yield components, spike length and weight were also affected by the cutting treatments. The reduction was 4.6 and 14.9 per cent respectively for crops cut twice. Season of production played an important role. Plants with prolonged vegetative phase had higher length and weight of spike compared to others. The number of fluff $spike^{-1}$ and hundred fluff weight were also significantly reduced by cutting treatments.

Fig. 1. Influence of dates of sowing and cutting treatments on 50 per cent flowering and seed germination



The reduction was more pronounced in crops raised during hot weather period than monsoon period. Reduction in photosynthetic source miht have resulted in reduced spike length and weight. Chaffy seeds were more in the spikes harvested from the clipped stands. The results were in conformity with the findings of Deo and Rai (1975) in oats and Stur and Humphreys (1987) in *Paspalum plicatulum.* Diego *et al.* (1995) reported 62 per cent decrease in number of seeds panicle^{-1} with three cuts and five percent in two cut crops compared to uncut crops.

Irrespective of seasons, seed yield was the highest in the seed crop with no cut for fodder. The yield reduction was minimum in the crop cut once for fodder than the crop cut twice if weather was favourable for seed set. Deo and Rai (1975) and Taneja *et al.* (1981) in oats also recorded less variation for seed yield in the fodder cum seed dual crop due to the compensatory effect of increased number of tillering and reduced lodging. Diego *et al.* (1995) also reported that in pearl millet and elephant grass hexaploid hybrids two cuts per year did not affect the seed yield but three cuts per year reduced the seed yield. Garcia *et al.* (1990) and Yadav and Rajora (1999) reported similar results with *Cenchrus ciliaris* seed crop.

Interestingly, in the crop sown on June 5th with no cut treatment and the crop sown during January 30th, the crop given two fodder cuts had the seed maturation phase coinciding with favourable weather conditions of low rainfall and bright sunshine hours. In the 1st crop no cut treatment recorded 256.37 kg ha^{-1} whereas the 2nd crop two cut treatment registered the maximum yield of 151.90 kg ha^{-1} clearly revealing that cutting reduces the physiological potential of the plant lowering the seed yield in the subsequent seed crop.

Pure seed crop sown on June 5th, without forage cutting recorded maximum seed yield. However, if cutting is done it should be so planned that the seed crop growth occurs during favourable climatic conditions. Apart from monsoon rains, pure seed crop received the intermediate day length of 11.8 to 12.4 during the reproductive phase which favoured the plants to flower more strongly than shorter or longer day length (Loch *et al.*, 1999). *Cenchrus grass* is classified as a crop requiring intermediate day length for flowering (Nada, 1980).

Seed crop with no cut for fodder sown during 30th January experienced extreme temperature of 34-35°C during flowering which might have reduced the seed set and seed yield. Similar results were reported in *Paspalum dilatum* (Pearson and Shah, 1981) and *C. ciliaris* (Loch, 1999).

The crop sown during June 5th which received fodder cuts twice, matured during November 2000, recording very low seed yield of 37.1 kg ha^{-1} due to the high relative humidity coupled with rains during seed setting period favouring disease incidence affecting the seed yield considerably. Huth (1996) recorded ergot disease incidence in *C. ciliaris* due to the higher relative humidity combined with greater incidence of showery weather. Rao and Singh (1994) reported that the rainfall during the flowering / seed setting stage resulted in lower seed yield in *Cenchrus ciliaris*.

Correlation studies on weather parameters clearly showed that differences in seed yield was greatly influenced by the sowing dates (Table 47). It could be inferred therefore, that weather factors such as temperature, day length and sunshine hours played a greater role either directly or indirectly in the expression of yield than any other source of variation (cutting treatments) in yield.

Data in the table demonstrated that RTD and HTU possessed significantly negative correlation during its vegetative phase in the pure seed crop. Thus it showed that the high day time temperature and low sunshine hours during the vegetative phase affected the seed yield causing loss of early phenological potential for biomass

Table 47. Simple correlation coefficient (r) between seed yield and thermal indices.

Variables	Seed crop (S)		Fodder – Seed crop (FS)			Fodder – Fodder – Seed crop (FFS)			
	Vegetative phase	Maturity phase	Vegetative phase I	Vegetative phase II	Maturity Phase	Vegetative phase I	Vegetative phase II	Vegetative phase III	Maturity Phase
RTD	-0.763 (3.73)*	-0.059 (0.187)	-0.409 (1.56)	-0.409 (1.42)	0.0136 (0.043)	-0.273 (0.896)	-0.392 (1.46)	0.078 (0.249)	0.551 (2.09)
GDD	0.352 (1.27)	0.137 (0.438)	0.309 (1.03)	0.491 (1.78)	-0.544 (2.05)	-0.721 (3.29)*	-0.073 (0.231)	0.154 (0.490)	0.986 (18.91)*
HTU	-0.810 (4.37)	-0.365 (1.24)	-0.807 (4.32)*	-0.590 (2.31)*	-0.391 (1.34)	0.323 (1.08)	0.5562 (2.12)	-0.525 (1.95)	0.889 (6.15)*
PTU	0.473 (1.70)	0.115 (0.37)	0.432 (1.52)	0.437 (1.54)	-0.671 (2.86)*	-0.706 (3.16)*	-0.043 (0.14)	0.365 (1.24)	0.988 (19.92)*

* 5 per cent significance

accumulation. In the dual crop of fodder cum seed too GDD, HTU and PTU showed highly significant negative correlation during its vegetative phase but positive correlation was recorded during the seed maturation phase. This implied that the seed maturation period needed higher temperature for proper seed filling and shorter day length with higher relative humidity favoured the disease incidence, affecting seed yield. Humphreys and Riveros (1986) also suggested higher levels of incident radiation for increased seed production potential.

Seed germination was not affected by dates of sowing, but the cutting treatments had greater influence on the seed quality when the seed crop was preceded by fodder cut twice than once (Fig.1). It reduced the germination to the tune of 16.4 per cent. The shoot length of the seedling and vigour index values were influence by both the dates of sowing and cutting treatments. This might be due to the true seed size variation in the fluffs since the fluffs from the cut crops had smaller sized seeds than uncut crops probably because cutting treatment might have reduced the vigour of the plant. Deo and Rai, (1975), Thakral *et al.* (1993) and Verma *et al.* (1992a) also reported the highest percentage of germination, seedling length and drymatter production of oat seedlings from uncut treatments.

From the above results it could be concluded that on monetary returns basis, dual crop is beneficial than the pure seed stands. Cutting at proper stage of the crop with proper season for subsequent crop growth and seed maturity would yield more than the pure seed stands.

For assessing the opt season for better seed production, an attempt was made to develop a model to predict the seed yield with the given set of meterological parameters. Regression analysis was performed on different set of agrometerological parameters in various phenophases as causal variable and seed yield as responsive variable.

Six different models for all the three crops *viz.*, seed crop (S), fodder – seed crop (FS) and fodder-fodder-seed (FFS) crop were developed for the prediction of seed yield (Table 48). In these models when a chi-square test was attempted (Fig. 2) a close agreement between the observed and predicted yield was supported by the lowest chi^2 values for model II and VI and these models can be practiced for predicting the seed yield of FS and FFS crop of *Cenchrus glaucus* cv. CO 1.

5.2. Seed development and maturation studies

Quality of a seed is basically dependant on seed filling and on the metabolic and synthetic efficiency during seed development and maturation which in turn is reflected upon the germination and vigourous growth of the resultant seedlings. Time and method of harvest are important components of herbage seed production, because these can affect the quantity and quality of seed obtained. In this context, it would be beneficial to know at which stage of development, the accumulation of dry matter in the seed terminates, the rate of respiration of the seed at that moment and amount of seed lost by delayed harvest (Anderson and Anderson, 1980).

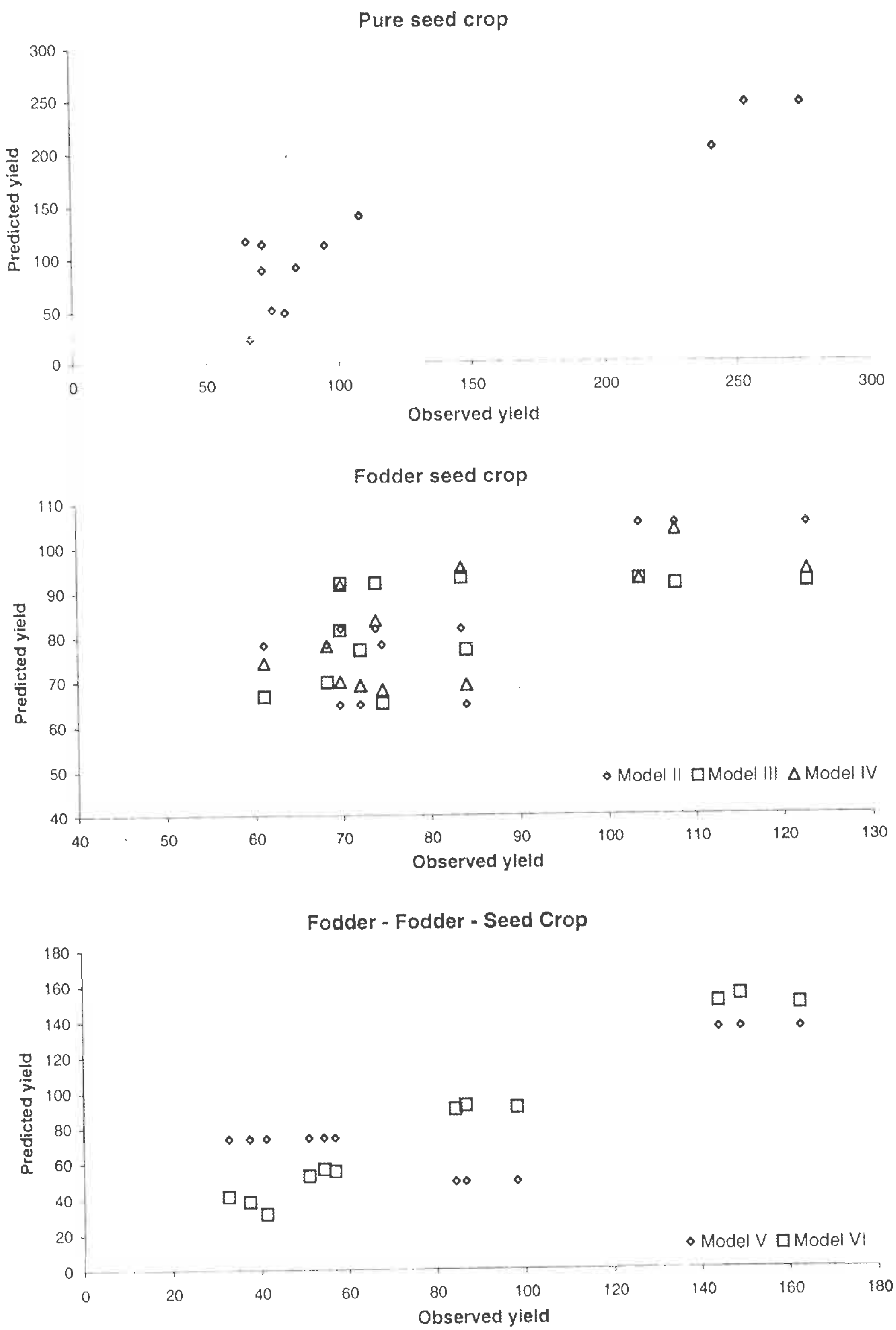
The state of maturity of seed crop when harvested is known to be the major factor responsible for variations in seed size, viability and vigour. The seed harvested at optimum maturity will be possessing maximum germination and vigour and thereafter, seed quality declines due to various reasons (Harington, 1972). For determining optimum stage of harvest, it is essential to know the physical and physiological changes that occur during seed development and maturation under varying periods (Pollock and Roos, 1972).

Seed maturation refers to the morphological, physiological and functional changes that occur from the time of fertilization until the matured ovules are ready for harvest (Delouche, 1973). Abdul-baki and Baker (1973) further differentiated seed development and maturation. Seed development is the period between fertilization and maximum fresh weight of seed and seed maturation begins at the end of seed development and continues upto harvest.

Table 48. Regression Model

S. No.	Model	R^2/r^2
1.	$Y = 1053.452 - 0.15026\ RTD_{(S\ veg.)} - 0.08173\ HTU_{(S\ veg.)}$	0.8384
2.	$Y = 318.1668 - 0.03107\ HTU_{(FS\ veg.\ 1)}$	0.6508
3.	$Y = 133.6611 - 0.00953\ HTU_{(FS\ veg.\ 2)}$	0.3485
4.	$Y = 211.751 - 0.00964\ PTU_{(FS\ mat.)}$	0.4496
5.	$Y = 326.475 - 0.18541\ GDD_{(FFS\ veg.\ 1)} - 0.00134\ PTU_{(FFS\ veg.1)}$	0.5201
6.	$Y = 2.3719 + 0.01078\ GDD_{(FFS\ mat.)} - 0.0008\ HTU_{(FFS\ Mat.)} + 0.00538\ PTU_{(FFS\ Mat.)}$	0.9762

Fig. 2. Comparison between observed and predicted seed yield (kg ha^{-1}) in *C. glaucus* cv. CO1



Seed ripening process in cereals and grasses has been studied by several workers (Frey *et al.*, 1958; Hyde *et al.*, 1959; Anslow, 1964; Hill and Watkin, 1975; Pegler, 1976; Anderson and Anderson, 1980). According to them, the ripening process can be divided into three principal phases. First, the percentage moisture falls from 80 per cent to 55 per cent, but there is an increase in total moisture content, total fresh weight and total amount of dry matter. In the second phase, fresh weight and total moisture content are nearly constant; the amount of dry matter increases and the moisture content falls from about 55 per cent to about 40 per cent. In the third phase, the real ripening period, the amount of dry matter is almost constant, but total moisture content, fresh weight and percentage of moisture decrease. The ripening period is shorter at high temperature than at low temperature regimes (Sharif Zadeh and Murdoch, 2000).

In the present study, spike length measured at 3 day interval after anthesis showed marginal differences during the period of development and maturation. The significant increase in length was observed only upto 9 DAA, then the changes were negligible. This finding was in conformity with the results of Narayanasamy (1994) in deenanath grass and Krishnan (1993) and Krishnarajan (1996) in guinea grass.

Plants differ in blosoming pattern and in the formation and development of seeds within a single inflorescence. The ears or spikes of some of the cereal crops observe centripetal succession in flowering forming the most productive seeds in central part of the spike as in maize (Elgawad *et al.*, 1998). The panicle of rice, sorghum and oats observed basipetal flowering pattern resulting in better quality seeds in the top and middle than in bottom portion (Senthilkumar, 1976).

Cenchrus inflorescence is a spike having centripetal flowering succession. The time taken for completion of flowering is only 2-3 days after the start of anthesis. Even this narrow time lag was reflected on the quality of seeds in different portions. In this study, the distal portion fluffs registered single seeds compared to 2-3 in middle and proximal portions.

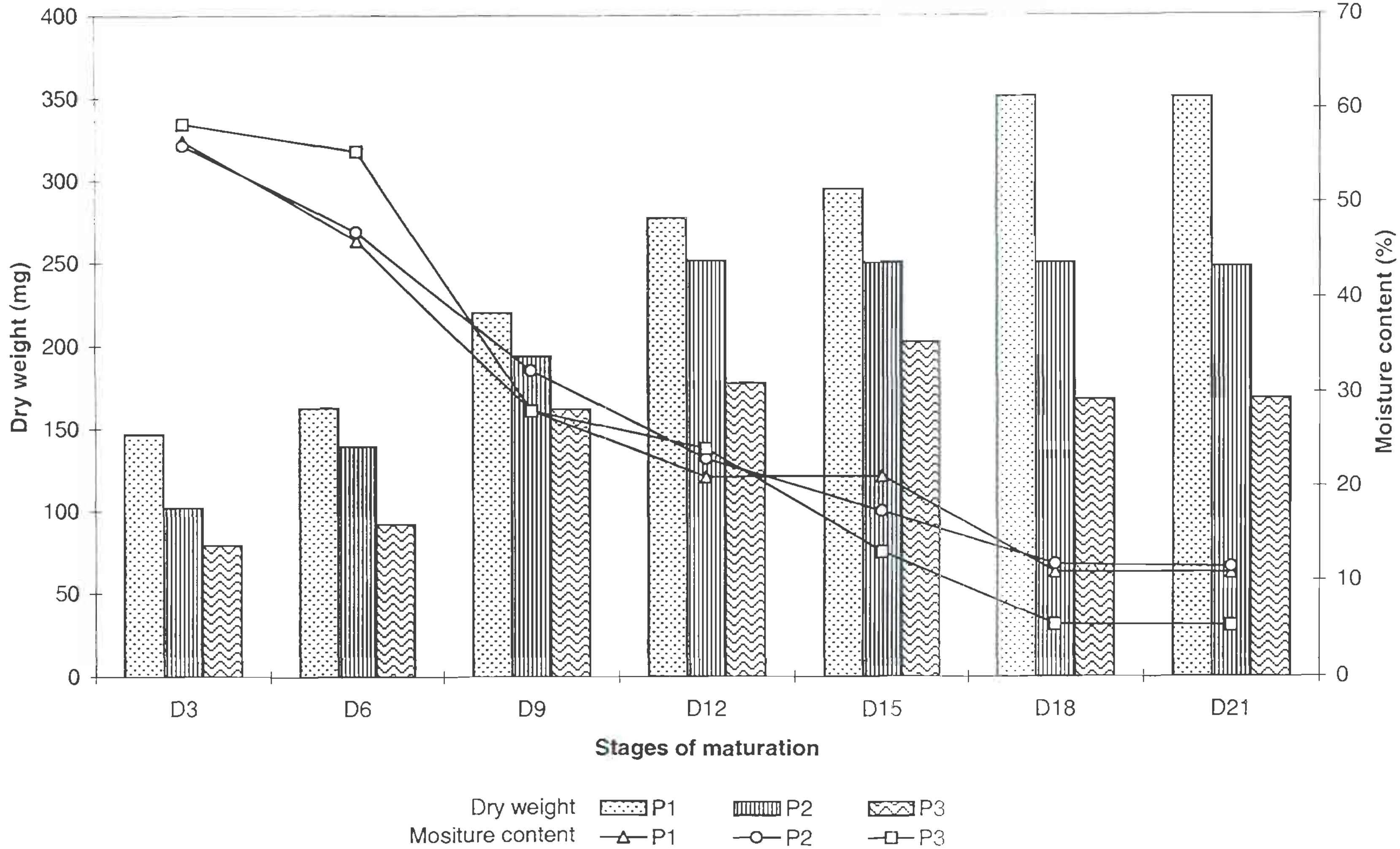
The reduction in moisture content of spike and fluff as seen in the present study was mostly physical (Prokojev, 1968) and occurred due to the moisture equillibrium between the seed and its surrounding atmosphere. The moisture content of spike and fluff showed rapid reduction with the advancement in the development of fluff upto 12 DAA. This study also revealed that the spikes or fluffs from the proximal and middle portion recorded higher moisture content than the distal portion. The decrease in moisture content was associated with the development of seed within the fluffs as evident from the corresponding increase in the dry weight of spike or fluffs (Fig. 3). Egli and Tekrony (1997) reported that moisture content of maize seeds increased to the maximum before the seed reached its maximum dry weight and declined gradually after physiological maturity. The reduction in moisture content might also be due to dessication and dehydration (Abdul-Baki and Baker, 1973) and oxidation and volatilization (Harington, 1972). Similar trend of moisture reduction was noticed in many grass species by several workers (Anderson and Anderson,1980 , Narayanasamy, 1994 , Krishnarajan, 1996).

The number of fluffs spike^{-1} showed nil variation during seed development and maturation. But middle portion of spike recorded the highest number of fluffs followed by the distal end and the lowest in proximal portion. The proximal portion fluffs contained 2-3 seeds fluff^{-1} while the middle portion contained only 2 seeds fluff^{-1}. Similar differences among the portions were noticed in deenanath grass (Narayanasamy, 1994).

Maximum fresh weight of the spike and fluff was recorded at 15 DAA marking developmental phase and beyond that the fresh weight decreased gradually indicating the maturation phase of the spiklets.

The dry weight of the spike and fluff was maximum at 18 DAA. But in the proximal portion, in which the dry weight accumulation continued to increase until 21 DAA, probably because anthesis in the proximal portion occured two to three days

Fig. 3. Dry weight and moisture content of fluffs during seed development and maturation



later than in the middle. The approach of physiological maturity closely coincides with maximum dry weight accumulation in most of the crops (Hyde *et al.*, 1959; Hill and Watkin, 1975) and thus it could be concluded that the seeds in the present study attained physiological maturity at 18 DAA particularly in the middle and distal portions of the spike. Sharma *et al.* (1999) recommended collection of the fluffs from upper portion of the spike immediately after maturation and the rest of the portion at later dates to avoid the loss of the valuable seeds due to shedding. Abd-el-gawad *et al.* (1998) reported that fresh weight of maize attained its maximum 38 days after pollination but dry weight accumulation continued to increase upto 41 DAA. In sorghum, Gowda and Gowda (1996a) observed a similar trend of gradual increase in dry matter accumulation till maturity.

Fresh and dry weight of the spike and fluff was more in proximal portion compared to middle and distal portions. Probably because seeds in proximal portion had a comparative advantage of closeness to the flag leaf an important source of photosyntates. Similar variations were observed in wheat ears in which the basal portion grains had maximum dry weight and the apical grains had the minimum dry weight (Chanda and Singh, 1998).

The number of filled seeds fluff^{-1} showed a gradual increase and it attained maximum at 15 DAA. The fluffs from the proximal portion of the spike had more number of filled seeds compared to other portions. The distal portion was having minimum number of filled seeds with higher number of empty fluffs, probably because early flowering in the proximal and middle portion of the spike would have enabled better accumulation of food reserves due to better source-sink effect depriving the seeds of distal portion for the photosynthates from the source.

Hundred true seed weight was also more for seeds from the proximal and middle portions than the distal ones due to better accumulation of nutrients. Similar pattern of seed weight was noticed in maize by El-gawad *et al.* (1998).

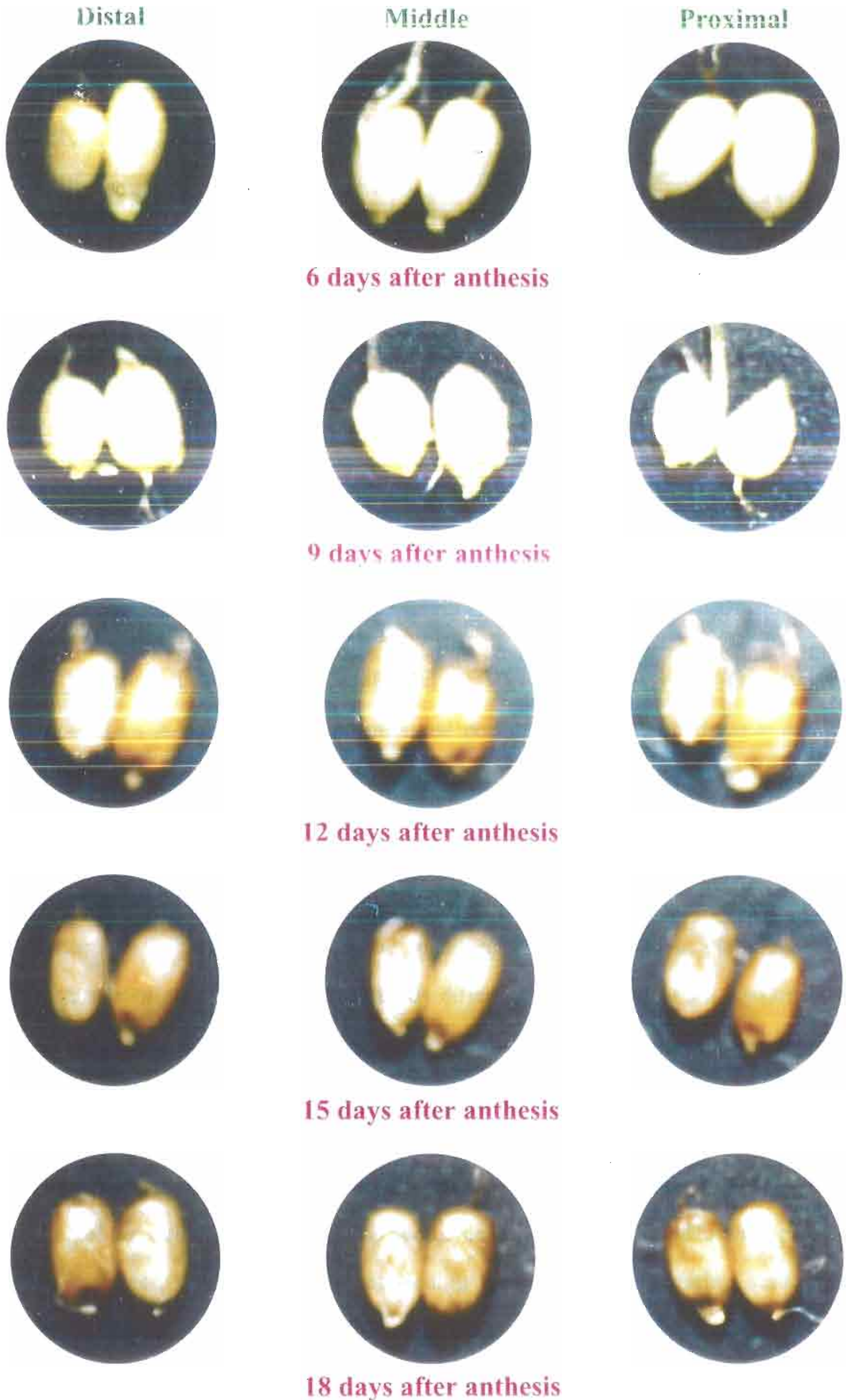


Plate 3. Seeds of *C.glaucus* at various development stages

The immature seeds obtained at the early stages failed to germinate. Seeds obtained 12 days after anthesis only germinated, reaching the peak at 18 DAA (Fig. 4). It was at this stage that the dry weight of fluffs was also at maximum. But Singh and Yadav (1986) recorded 10-18 per cent germination from the seeds collected at four days after anthesis in both *Cenchrus ciliaris* and *C. setigerus* which peaked at 12-16 DAA (30 per cent).

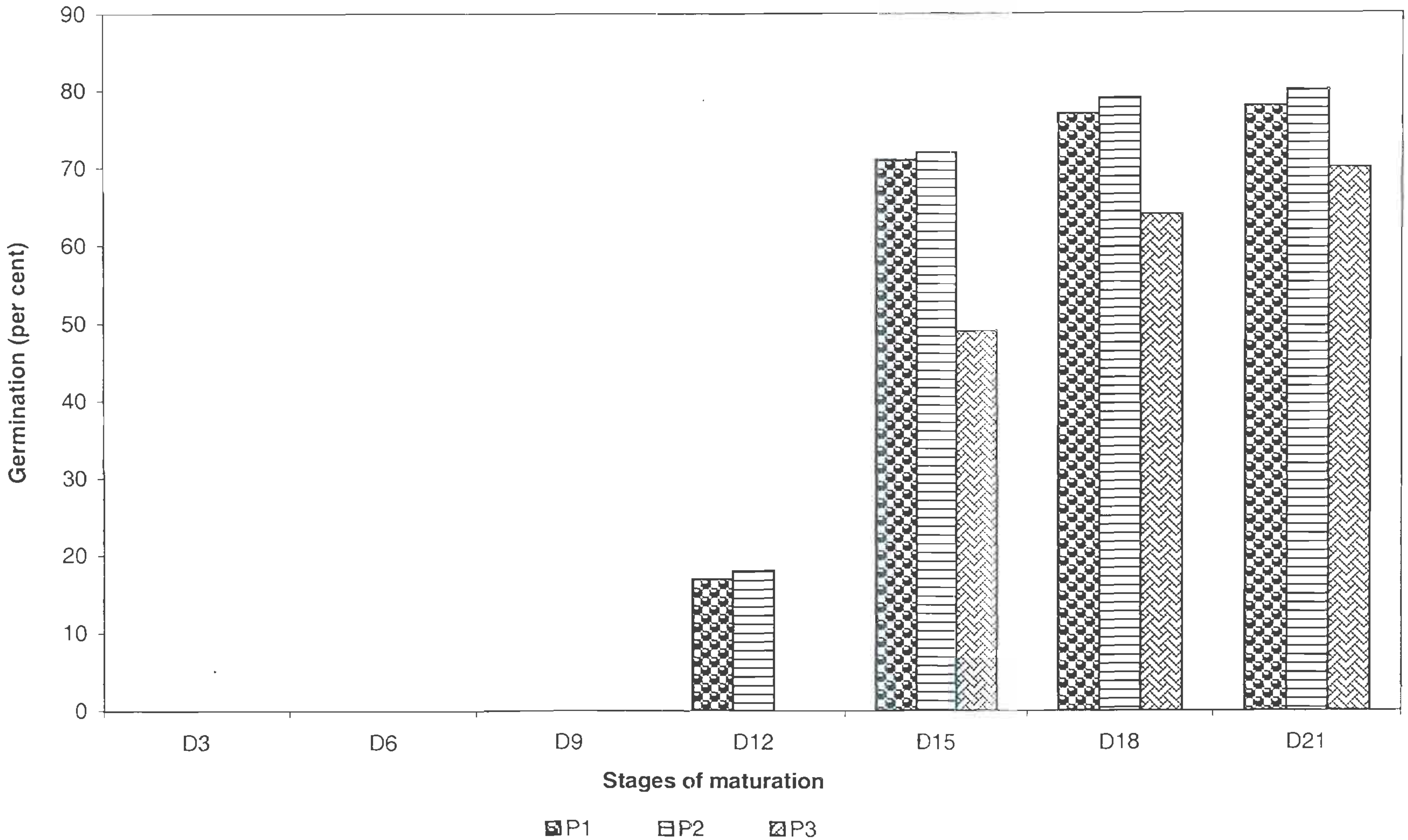
Seeds from the middle and proximal portions registered higher germination than those from distal portion (Fig. 4). Probably because of better accumulation of nutrients in these seeds, which had also reflected on weight. Similar results were reported by Angamuthu (1991), Narayanasamy (1994), Rabanal *et al.* (1994), Peterson *et al.* (1995) and Krishnarajan (1996).

The results thus suggested that the fluffs of *Cenchrus glaucus* cv. CO 1 attained maturity at 18 DAA and middle and proximal portion of the spike had better quality seeds. Delayed harvest beyond 21 DAA resulted in shedding of the valuable seeds to a greater extent.

5.3. Seed quality in relation to tillers

Location of seed formation in the spike creates heterogenity in the quality not only because such seeds are formed in slightly different kind of internal environment, but also they have a differential supply of essential nutrients for life (Ovcharov and Kizilova, 1966). Similar variability in quality could be expected in the seeds from different tillers of the plant. Normally, late formed tillers produce the shortest spike with more number of ill filled or chaffy seeds (Hacker, 1999). This uneven heading and flowering of the tropical grasses leads to poor synchronization of the maturation process and late emerged heads have poor set leading to low pure germinating seed yield (Booman, 1980).

Fig. 4. Germination of seeds from different portions of the spike during seed development and maturation



The spike length was normal upto sixth tiller and thereafter it started declining. The number of seeds fluff^{-1} was maximum for the fluffs from first tiller followed by third, forth and fifth formed, tillers. The number of seeds were low in the second tiller compared to other tillers probably due to the reason that the time gap between the first and second tillering was less as compared to that among other tillers. Similar trend was noticed for hundred fluff weight. The first, third and fourth tillers registered higher fluff weight. Seventh tiller recorded the lowest fluff weight probably because of exhaution, which the plants might have experienced.

The fluffs contain both large and small seeds and the large seeds recorded higher germination and the increase was to the tune of 7.2 per cent compared to smaller ones. Similar dimorphic seeds and significant growth differences of their seedlings were observed by Lahiri and Kharabanda (1961) in *Cenchrus ciliaris, C. setigerus* and *Lasirus hirsutus*. Germination of seeds from first six tillers were higher than that of late formed tillers. Interestingly, germination of seeds in the second tiller was on par with the first tiller whereas significant dip in the fluff weight of second tiller was noticed.

Fluffs from all tillers possessed initial dormancy of three months and started germinating after that three months. Thereafter, fluffs showed gradual increase in the germination per cent. The late formed tillers (5^{th} and 6^{th}) registered the highest germination of 85 and 82 per cent at nine months after storage. The early formed ones (1^{st} - 4^{th}) recorded a germination of 70-76 per cent only, showing differential release of dormancy in the fluffs of different tillers. Narayanasamy (1994) in deenanath grass recorded the reverse trend in the release of dormancy of fluffs from different tillers. This evidently indicated the polymorphic nature of the fulffs in their germination behaviour among the tillers. The very late formed tillers (7^{th} and 8^{th}) showed lower seed germination during storage probably due to low seed quality as evident in low fluff weight also.

Hence, it could be concluded that the fluffs from the first six tillers might be collected for seed purposes.

5.4. Influence of media and temperature on seed germination

The germination test requirements are top of the paper or sand medium at 20-35° or 20-30°C for *Cenchrus ciliaris* as per ISTA Rules (ISTA, 1999). In the present study *Cenchrus glaucus* seeds behaved differently at high temperature. Emergence was very early at 30°C and the seedlings were not able to withstand the full length of the germination period of 14 days. Between paper method produced more vigourous and lengthier seedlings than the top of paper method. In the earlier studies too, difference of opion was expressed by various workers on the temperature requirement for germination of *Cenchrus ciliaris*. Lahiri and Kharabanda (1964) indicated that germination of *C. ciliaris* occured better at temperature in excess of 30°C than at 25°C. Al-ani and Ouda (1969) reported that increase in temperature had positive influence on germination of *Cenchrus ciliaris* and *C. setigerus* and recommended 25-30°C. But Low (1981) recommended KNO_3 soaking as a pre treatment and an alternate temperature of 20-35°C for testing buffel grass. Hence, the present study was initiated with different media *viz*., TP, BP and sand at different constant and alternate temperature regimes to fix suitable medium and temperature for *C. glaucus* seeds.

In the present study, constant (20°C) or alternate (20-30°C) temperature increased the days required for initiation of germination. It also reduced the germination per cent, speed of germination seedling growth and vigour index irrespective of the medium used for seed testing. Similar results of reduced growth and germination by low temperature was reported by Kurdikeri *et al.* (1995) in maize.

The seeds kept at 20-30°C alternate temperature regime when brought to 25-30°C recorded higher percentage of germination. Pandeya and Jeyan (1978) also observed nil germination of *Cenchrus ciliaris* at 15°C for 20 days but recorded 38 per cent germination when the seeds were brought back to laboratory conditions.

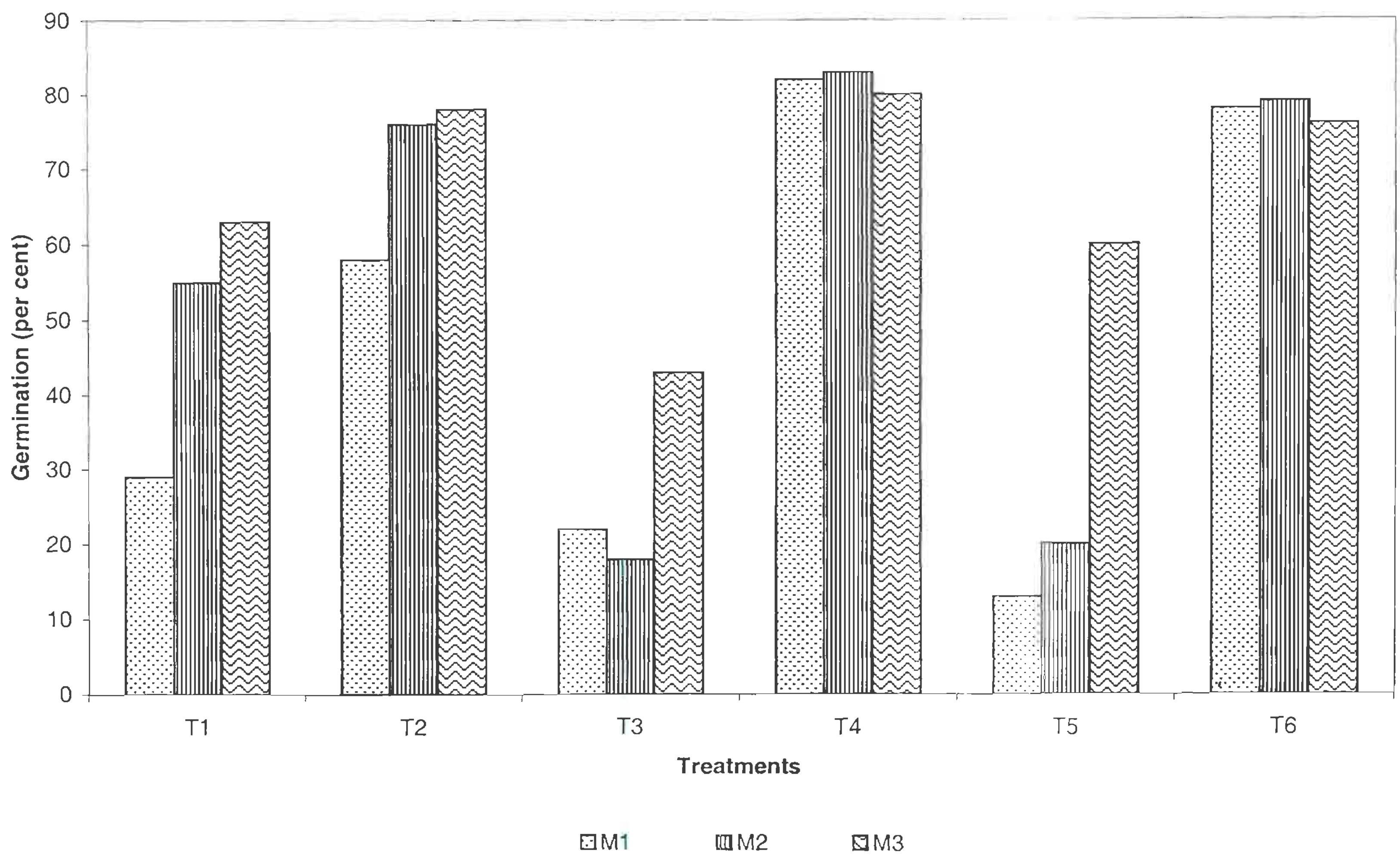
Seeds germinated faster at a constanst temperature of 30°C than at lower temperature of 20 or 25°C. However, at the end of the test period most of the seedlings were decayed and dried due to high temperature. Pandeya and Pathak (1978) also observed reduced mean time for germination of *C. ciliaris* seeds when germinated at 30°C.

The alternate temperature of 25-30°C recorded the minimum of 2.5 days for the radicle emergence. In addition, the speed of germination, seedling length and vigour index were the highest in this temperature range eventhough the final germination was lower (4.9 per cent) than the seeds germinated at 20-25°C range (Fig. 5).

Grass seeds germinated better at the alternate temperature regimes than at constant temperature. Carneiro (1994) recorded higher germination of *Brachiaria brizantha* seeds at 25/30°C than at constant 25°C. Schrauf *et al.* (1995) observed more germination at 20-30°C than at 25°C in *Paspalum dilatum*. Most of the native grass species of New South Wales also germinated to maximum at an alternate temperature of 20-30°C (Grice *et al.*, 1995). Butler (1985) recommended constant 25°C or alternate 20-35°C for better performance of *C. ciliaris*.

Physical condition of the germination medium is an important factor as they determine the media plant-water relationships, aeration and mechanical impedance to root and shoot growth. In the present study, among the media for germination both sand and between paper medium performed well compared to top of the paper medium. The vigour of the seedlings was also better in both sand and between paper media, eventhough the time taken for emergence was more for the sand medium. Torres and Mello (1994) recommended alternate temperature of 20°-30°C in sand media for *Gliricidia* germination. Ahuja and Bhimaya (1967) recommended sand medium for germination test in *Panicum antidotale, Lasirus sindicus, Cenchrus ciliaris, C. setigerus* and *Dichanthium annulatum*.

Fig. 5. Effect of temperature and media on seed germination in *C. glaucus* cv. CO 1



It could be concluded that sand and between roll towel medium and 25-30°C alternate temperature are the best for *C. glaucus* seed germination.

5.5. True seed extraction techniques

Cenchrus grass seeds are chaffy and sold in the form of 'fascicles' called as fluff, each consisting of clusters of spiklets usually 1-3, surrounded by an involucre comprising two rows of wavy bristles. An individual spikelet consists of 2 papery glumes and 2 florets each with soft papery lemma and palea. The caryopses or true seeds are present inside the glumes. The chaffy seeds are light and bulky and do not flow freely because the individual units tend to become entangled. These attributes add to the costs of cleaning, testing, storage and transport and make it impossible to sow chaffy seeds evenly through conventional seeders. Besides, the fresh fluffs hinder the germination if sown as such. Further more it is not known whether the fluff really contains any matured seed inside - all hidden by the covering structures. Hence the glumes are to be removed to get true seeds.

In this study, to extract the true seeds, the precleaned fluffs were subjected to different extraction methods *viz.*, manual, mechanical and acid.

The seeds extracted manually and mechanically registered higher recovery. The extraction by acid digestion for 20 min. yielded more seed recovery of 56.71 per cent than the lower duration of 10 min. but longer duration damaged the seed by coroding the seed coat. Complete digestion of glumes occured at 16 to 20 minutes duration and the recovery of seeds at 16 min. duration was 4.45 per cent lower than at 20 min. with minimum damage to seeds. Although manual defluffing was the best with nil damage combined with higher seed recovery and quality, it is not practically possible for large scale adoption. In the mechanical defuzzer too, more of abrasions were caused by sand particles used for defuzzing. Hence, the alternate method is the acid defluffing for 16 min.

In acid defluffing the concentration and the duration of the treatment are very important, which reflected on the seed recovery and quality of the seeds. Although the seed recovery was lower at lower duration of 10 min., seed germination and vigour of seedlings were higher.

Narayanasamy (1994) extracted the true seeds of deenanth grass in a mechanical defuzzer with higher seed recovery associated with better seed quality.

Hence from this study it was concluded that true seeds (caryopses) of *Cenchrus glaucus* could be extracted by using commercial grade sulphric acid @ 480 ml kg^{-1} of seed for 16 min.

5.6. Seed quality upgradation

Cenchrus seeds are fluffy and each fluff consists of 1-3 caryopses surrounded by wavy bristles. These chaffy seeds are light and bulky and do not flow freely because the individual units tend to become entangled. Hence fluffs were treated with commercial grade sulphuric acid for 4 min and washed thoroughly with water. The seeds were dried to its original moisture and this greatly reduced the bristles of the fluffs. By removing the appendages bulk of seed was reduced and seed density and flowability were improved. Further processing operations were relatively gentle and seed germination was improved. For upgrading the quality of the seed lot by eliminating the chaffy seed units further these acid digested fluffs were fed to the specific gravity separator.

In the present study, grading of *cenchrus* fluffs based on size could not be made to obtain improvement in seed germination. Since single fluff is having varying number of seeds (0-4), an attempt was made to separate the seeds based on specific gravity of the fluffs by using the specific gravity separator. The specific gravity separator works on the principle of flotation. A combination of shaking and air flow upthrough the deck causes the seeds to stratify according to the specific gravity producing a layering effect. The heavier particles move to the top, lighter particles to the bottom and the lightest seeds float down under gravity and are discharged at the lower end whilst, the heaviest ones are kicked up by the slope by contact with the oscillating deck and discharged at the upper end. Before resorting to actual separation of seeds, the optimization of the machine was found necessary in order to obtain perfection in seed separation. Accordingly, the end and side slopes of the deck were fixed by the vertical (0, 0.5, 1 and 1.5) and horizontal (0,1) scales and the air flow rate adjustments were set at 3rd and 4th levels. Since the air flow rate at first and second levels was not sufficient to stratify the seed layer.

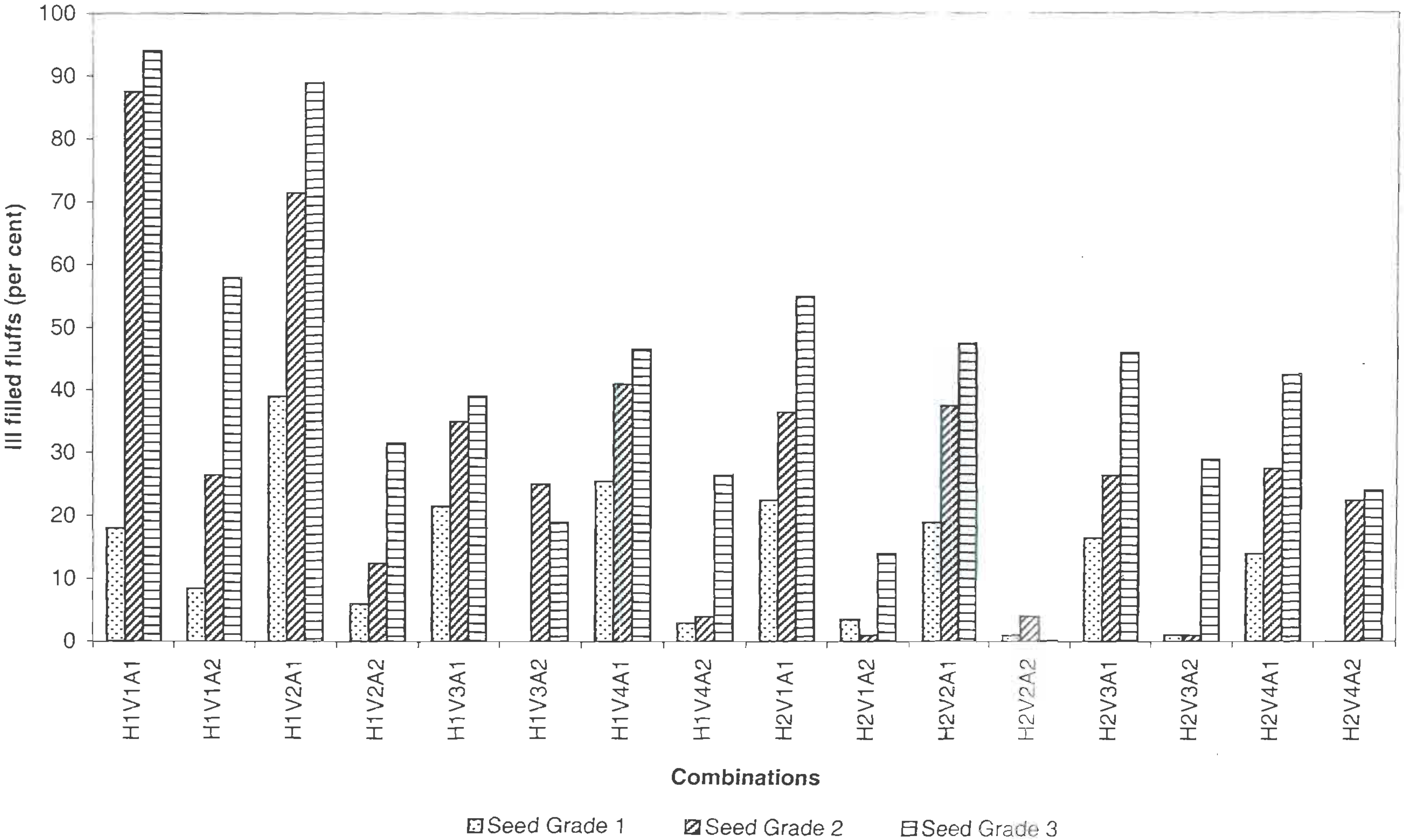
Of the 16 different settings tried, seeds were separated properly into five grade classes in 10 types of settings. In any particular adjustment of both the scales the air flow rate adjustment level at 4 was found to be the best for proper separation of ill filled fluffs in the seed lot which reflected on the percentage of ill filled fluffs present in different grades of seeds.

The seed recovery was higher at 0 level of horizontal scale adjustment than at the level of 1. Among the vertical scale adjustments, level at 0.5 registered more percentage of heavy fluffs (G_1).

The adjustments for the end and side slopes of the deck, exhibited significant influence on hundred fluff weight. The horizontal scale of 1, irrespective of the vertical scale adjustments at the air flow rate of 4 registered increase in hundred fluff weight for the heaviest fraction of seeds. Fluffs collected at the spouts G_4 and G_5 were only ill filled fluffs and thus were not included for further observations.

The percentage ill filled fluffs, were higher at the G_2 grade with the air flow rate of 3 showing the inability of this air flow rate in the separation of ill filled fluffs. At the air flow rate of 4, minimum percentage of ill filled fluffs was observed at the horizontal scale level of 1, irrespective of the vertical scale adjustments (Fig. 6).

Fig. 6. Effect of various adjustment levels of specific gravity seperator on ill filled fluffs in*C.glaucus* cv. CO1



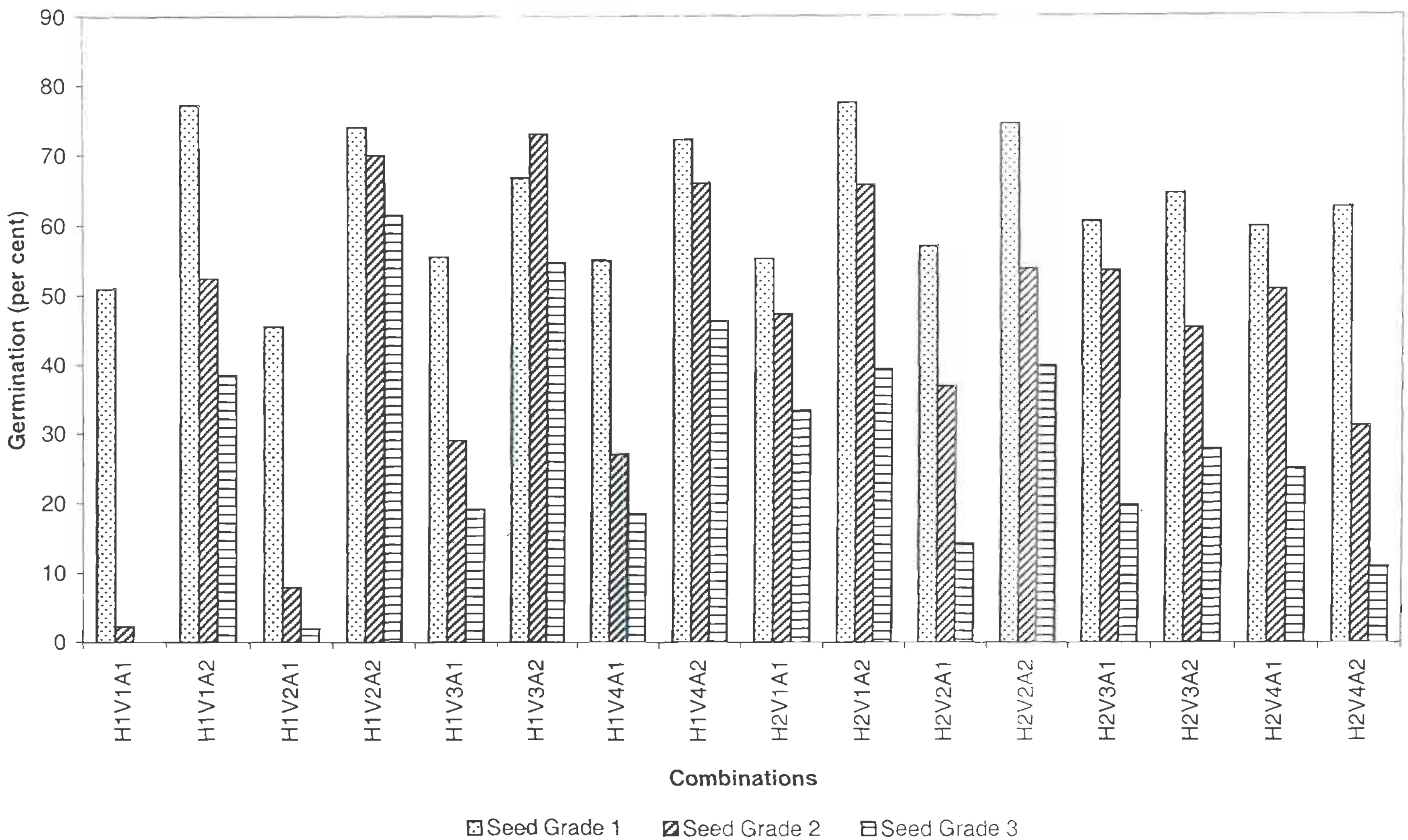
Seed germination as well as seedling vigour as measured through seedling length and vigour index revealed the beneficiary effect of specific gravity separation using the air flow rate of 4 and vertical scale adjustments at 0, irrespective of the horizontal scale adjustments (Fig. 7). The fluffs obtained at G_1 grade were superior to other grades. Patil and Sarode (1988) and Gowda and Gowda (1996b) in hybrid sorghum obtained heavier seeds with the highest 100 seed weight from the high spout level of the specific gravity separator and recorded higher germination with those seeds compared to low spout level seeds.

The fluffs obtained at G_1, G_2 and G_3 grades recorded the germination of more than 35 per cent which was well above the minimum seed certification standard of 30 per cent. Total seed recovery of fluffs under these 3 grades at the air blow rate of 4 worked out to 87.12 and 90.08 per cent at H levels of 0 and 1 respectively. The vertical scale adjustments which fixes the end slope of the deck did not significantly influence the quality of fluffs.

The heaviest seed fraction contained fluffs with 2-3 caryopses or large seeds and thus produced more number of vigorous seedlings. Lahiri and Kharbanda (1961), Arunkumar and Joshi (1970) and Lahiri *et al.* (1982) also recorded increased seedling length with large seeds of *Cenchrus* sp.

Hence, the present study revealed that upgradation of seed quality in terms of germination and vigour was possible through specific gravity separation. Similar upgrading of seeds through specific gravity separation was reported by Dharmalingam *et al.* (1973) and Khan (1976) in *Eucalyptus,* Infantini *et al.* (1992) in *Lotus corniculatus,* Umarani (1999) in *Casuarina*, Douglas *et al.* (2000) in Eastern gama grass and Anon. (2001) in cotton and sunflower.

Fig. 7. Effect of various adjustment levels of specific gravity seperator on seed germination in *C.glaucus* cv. CO1



5.7. Seed dormancy

Seed dormancy is the natural phenomenon for the survival of grasses in their undisturbed ecosystem. Unlike natural grasslands, modern arable pasture system needs to be frequently re-established as part of a rotational cropping system. The seed dormancy in forage grasses prevents successful establishment of a new pasture. The dormancy in one of the mixture of grass species in the pasture land can lead to complete elimination of the species during the establishment phase. Hence, breaking the dormancy of freshly harvested seeds is necessary for improving the germination.

Several studies have revealed germination improvement through acid scarification (James and Conard, 1973; Tischler *et al.*, 1994; Brecke and Duke, 1980; Ruiz *et al.*, 1996). The freshly harvested fluffs without any treatment recorded nil germination in the present study. Hence the fluffs were acid scarified for 4 min, washed with water, dried to original moisture content and then graded with the specific gravity separator, and used as control. The germination level in the acid scarified fluff was 42 per cent. The improvement caused by acid scarification might be due to the removal or disruption of lemma and plea allowing greater gas exchange or water movement into the seed for partial destruction or removal of specific germination inhibitors present in the freshly harvested seeds

Germination was further improved by 12.5 per cent when the scarified fluffs were soaked in water for 16 h. Water soaking might have leached out some of the inhibitors present in the husk resulting in germination improvement of the fluffs. Similar improvement in germination through acid scarification followed by water soaking was noticed in *B. brizantia* seeds (Montorio *et al.,* 1997).

Lahiri and Kharabanda (1963) investigated the germination inhibition mechanisms in *Cenchrus ciliaris, C. setigerus* and *Lasirus sindicus* and concluded that both *Cenchrus* and *Lasirus* fluff possessed inhibitors in the husk, which was the primary cause for the lower germination of fresh seeds. Similar results were obtained in the present study too, where the seed leachate obtained by soaking the spikelet tissue of *Cenchrus glaucus* inhibited the germination of true seeds of *C. glaucus* completely when the leachate was of higher concentration, whereas at lower concentration the effect was low and in fact enhanced the seedling growth.

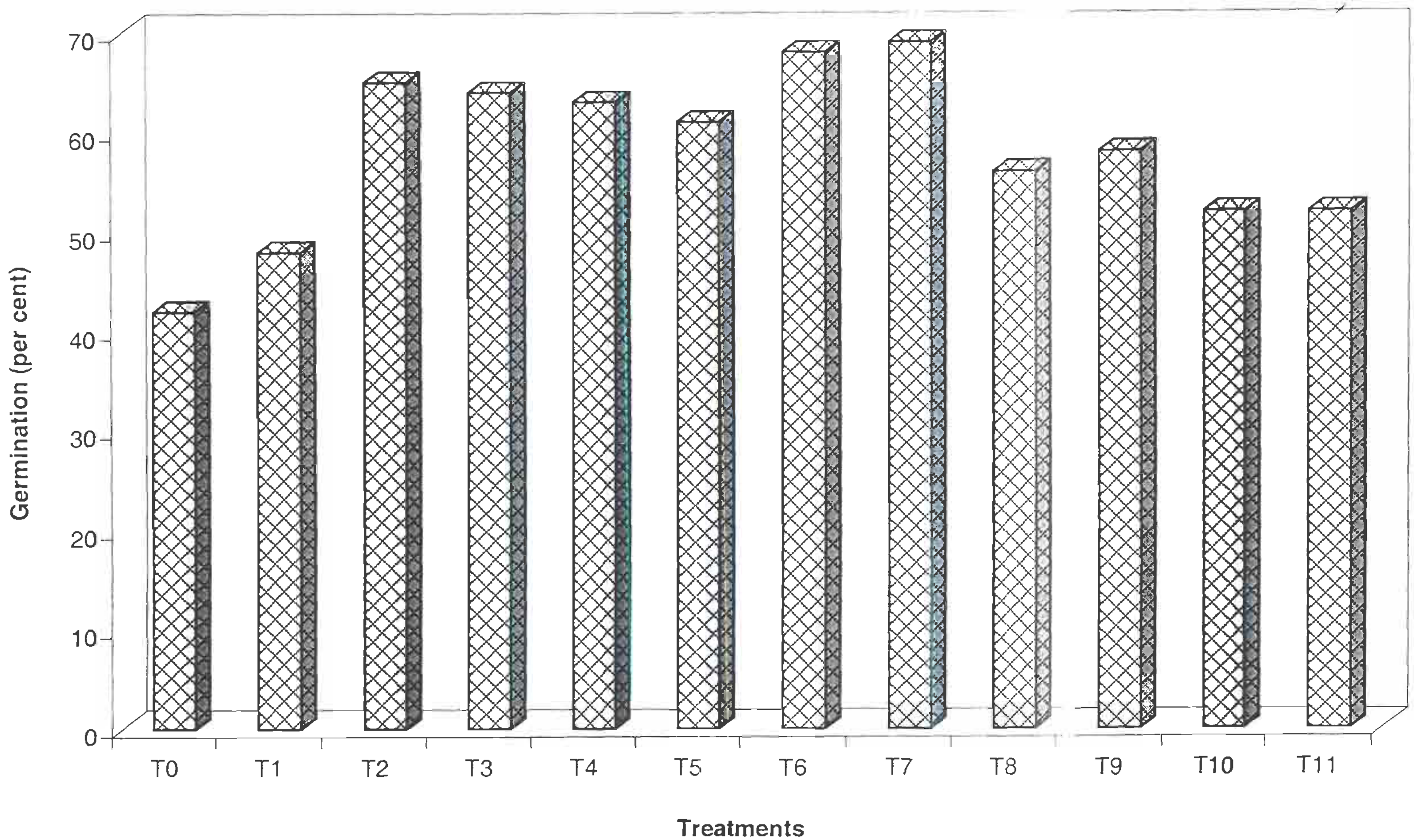
Pandeya and Jeyan (1978), Parihar and Kanodia (1984) and Parihar and Patil (1986) identified the water soluble phenolic inhibitor present in the spikelets of *C. ciliaris* and *C. setigerus* as acylated glycoside of cyanidin which inhibited the germination of true seeds more at high concentration than at lower concentration. Pandeya and Pathak (1978) also recorded the presence of phenolics particularly anthocyanins in fresh glumes and other phenolics in fresh seeds of *Cenchrus ciliaris*.

Further, the scarified fluffs were soaked in different concentration of different chemicals to break the residual dormancy in the fluffs.

Treating fluffs with ascorbic acid at 25 ppm significantly improved germination to an extent of 39 per cent over control followed by $CuSO_4$ at 50 ppm and KNO_3 at 0.5 per cent concentration (Fig. 8). Similar improvement in germination of *C. ciliaris* was noticed by Pandeya and Jeyan (1978) with ascorbic acid, copper sulphate and streptomycin.

Chatterjee (1960) in tung seeds (*Aleunite fordii*) and Umarani *et al.* (1997) in *Casuarina* also recorded improved germination with ascorbic acid over control. Delatorre and Barros (1996) reported that cadmium, copper and zinc at higher concentrations (10^{-2} M) relieved the physiological dormancy of partially released scarified seeds of *Stylosanthes humilis* and attributed the reason as ethylene production triggered by the free radical formation due to oxireduction reaction by the copper ions.

Fig. 8. Effect of dormancy breaking treatments on seed germination in *C.glaucus* cv. CO1



KNO_3 (0.5 per cent) soaking showed a germination improvement of 35.4 per cent over control. However higher concentration was less effective than lower concentration. Bhubathi *et al* (1983) reported the best dormancy breaking treatment for *C. ciliaris* as KNO_3 soaking and similar results were reported in Columbia needle grass (Young *et al.*, 1990), guinea grass (Previero *et al.*, 1996; Gonzalez and Torriente, 1983), *Brachiaria* sp. (Ruiz *et al.*, 1996), *Cenchrus echinatus* (Martins *et al.*, 1997) and *Paspalum notatum* (Herrera, 1994a).

KNO_3 is well documented as a compound which increases the germination of photo dormant seeds. *C. glaucus* seeds are not light requiring, however they responded to KNO_3 treatment. KNO_3 rises the ambient oxygen levels by making less oxygen available for citric acid cycle (Bewley and Black, 1983). Leadem (1987) concluded that enhanced germination due to KNO_3 was the outcome of quantitative and qualitative shifts in the protein synthesis.

Gibberellic acid at 100 ppm improved the germination of fluffs. Germination improvement with gibberellic acid was reported in many tropical grasses (Shahi and Sen, 1991; Singh *et al.*, 1995; Krishnarajan, 1996). Brahma *et al.* (1978) suggested that GA could counteract the inhibitory effect of abscisic acid and coumarin. The positive effect of endogenous or exogenous gibberellic acid in the germination process of seeds was to mediate in the release of endosperm food reserves (Paleg, 1965). According to Khan (1980), soaking of seeds in GA stimulates germination of those seeds which are in non deep physiological dormancy including the light sensitive seeds. GA plays an important role in the regulation of germination and in the release of dormancy.

Seed vigour measured through seedling length and vigour index were enhanced by GA_3 treatment possibly due to an increase in enzymatic activity on aleurone layer causing increased starch hydrolysis, which would have created extra supplies of reducing sugars (Paleg, 1960), increase in amylase activity (Kapur *et al.*, 1990), isocitrate, lyase and peroxidase activity and increase in protein synthesis and cell elongation in embryonic axis (Soliya *et al.*, 1991).

The results of tetrazolium test revealed that *C. glaucus* seeds possessed more than 90 per cent viability when it was fresh. But the dormancy breaking methods could not register 90 per cent germination. Maximum possible was 69 per cent with acid scarification followed by ascorbic acid treatment. Hence, in the present study, true seeds were extracted from the fluffs and subjected to dormancy breaking treatments of soaking in chemical solutions at different concentrations.

Germination level in the true seeds extracted from the fluffs was 62 per cent indicating that the dormancy level in the naked caryopses was lower than the whole fluff and that the spikelet structures surrounding the true seed possessed more inhibitory effect. This result was in conformity with the findings of Parihar *et al.* (1984a and 1984b), Vijendradas (1990), Venter and Rethman (1992) and Parihar *et al.* (1999b). Butler (1985) opined that dormancy mechanisms of *C. ciliaris* lies within the caryopses rather than in the associated structures of fluff.

The deglumed seeds soaked in $CuSO_4$ at 50 ppm and ascorbic acid at 25 ppm registered the highest germination of 80 per cent. Similar results were noticed with the true seeds of different ecotypes of *Cenchrus ciliaris* (Pandeya and Jeyan, 1978).

The highest shoot length of the seedlings was registered with GA treated seeds. Basra *et al.* (1990) reported similar results in guinea grass seeds. As said earlier GA application might have enabled the extra supply of reducing sugars by way of increased rate of starch break down, which resulted in increased growth rate of seedlings (Paleg, 1960). Whalley (1965) showed that the increase consisted primarily of root growth rather than the top growth. But in the present study the shoot length was improved (33.7 per cent over control) rather than the root length of the seedlings.

From the results of present experiment, it could be concluded that fluffs of *C. glaucus* should be acid scarified by soaking in commercial grade sulphuric acid for 4 min followed by soaking in $CuSO_4$ (50 ppm) or ascorbic acid (25 ppm) solution for 16 h to break its dormancy and obtain an improvement in germination. For breaking dormancy in true seeds soaking in $CuSO_4$ (50 ppm) or ascorbic acid (25 ppm) solution for 16 h could be followed.

5.8. Seed pelleting

Pelleting of seeds provides a convenient carrier for nutrients and also insecticides and fungicides (Dunning *et al.*, 1985). The idea of seed pelleting is to supply extra nutrients (Wyk and Van, 1983). Partial correction of the micronutrient deficiencies of the soil could also be possible through seed pelleting treatments (Ribeiro and Sandos, 1994). Pelleting provides a more regular shape, thus helping in precise planting and it facilitates an uniform field stand. Proper pelleting material favours desirable plant population with good stand establishment (Miller and Scooter, 1967).

In the present study, the fluffs were first scarified with H_2SO_4 for 4 min, dried and graded to facilitate proper pelleting of seeds, since cenchrus seeds are having bristles which inhibit proper coating of the pelleting material.

Seed germination was improved by $CuSO_4$ (7.4 per cent) and $FeSO_4$ (3 per cent) pelleting respectively. All other treatments were not able to improve the germination, at the same time had no deleterious effect on the germination except DAP and $MnSO_4$ which recorded 4.8 per cent lower germination than the control. Huanwen *et al.* (1998) registered increased germination, germination energy, germination index and root length of the seedlings from copper coated cucumber seeds. Riebeiro *et al.* (1994a) revealed that seed treatment with Zn or in combination with B–Bio Crop had no deleterious effect on germination and vigour of the maize seedlings and recommended for use in soils deficient in Zn or B. Ribeiro and Sandos (1994) reported that copper sulphate or manganese sulphate coating improved the germination of maize seeds. Narayanasamy (1994) recommended DAP pelleting for the true seeds of deenanath grass for easy handling and better establishment.

The root and shoot length of the seedlings and vigour index values were higher in the seeds pelletted with DAP in combination with either $FeSO_4$ or $ZnSO_4$. The beneficial effect might be due to the availability of phosphorus, Zn and Fe nutrients in the immediate vicinity of germinating seeds. These nutrients could aid the build up of biological energy required for the germination process. Similar results were reported by Jaisingh (1996), Younger and Gilmore (1979) and Ros *et al.* (2000). Silcock and Smith (1982) found that seed coating with water soluble sources of P to *Cenchrus ciliaris* improved the seedling growth under acidic sandy redearth soils.

Field emergence of the pelleted seeds also showed similar positive response as that of lab germination and seeds pelleted with DAP in combination with $ZnSO_4$ or $FeSO_4$ recorded higher dry weight of the seedlings after 30 days of emergence, because the pelleted seeds were supplied with nutrients near the root zone at the very early stage itself and thus might have helped in the vigorous plant establishment. Kim *et al.* (2000b) in *Poa pratense*, Hosmani *et al.* (1998) in *Stylosanthes*, Albert and Miller (1987) in bermuda grass, Young and Gillmore (1979) in *Cenchrus* registered similar improvement in field establishment and dry matter yield with the pelleted seeds.

Arappu leaf powder as a filler material was also noted to be a nutrient supplier, especially Zn, which synergistically increased the amino acid, tryptophan to form IAA. It corrects certain physiological disorders inside the seed. Moreover arappu leaf powder is reported to contain GA_3 and Saponin (Angamuthu, 1991).

The pelleted seeds could also be stored well, since *Cenchrus* seeds are naturally good storers. All pelleting treatments except DAP recorded 14 – 20 per cent more germination after three months storage including control. But DAP treated seeds recorded 11 per cent lower germination than control seeds. Probable reason for loss in viability of DAP coated seeds could be the toxic nature of the chemical (Bapat and Umale, 1973). Other micronutrients Zn, Fe, Cu, Mn and B had no deleterious effect on seed. Ribeiro *et al.* (1994b) stated that treatment with Zn - Bio-crop had no deleterious effect on maize seed quality but B - Bio-crop reduced germination and vigour.

Hence pelleting the scarified fluffs of *Cenchrus glaucus* using DAP @ 60 g kg^{-1} of seeds in combination with $FeSO_4$ or $ZnSO_4$ @ 10 g kg^{-1} of seeds, with arappu leaf powder as filler material could be employed for good plant establishment.

5.9. Seed storage

Cenchrus fluffs are bulky and to reduce the bulkiness and make them amenable for handling, the fluffs were treated with commercial sulphuric acid for 4 min, washed and dried back to about 10 per cent moisure. Varied views have been expressed on the storability of acid scarified fluffs. Buffel grass seeds treated with 24 M H_2SO_4 maintained its viabiilty in storage (Vierira-neto and Aragao, 1984), whereas scarified *Brachiaria brizantha* seeds showed greater losses in viability under long term storage (Previero *et al.*, 1998). Herrera (1994b) recorded better germination with KNO_3 treated *Brachiaria decumbens* seeds but not with H_2SO_4 treated seeds.

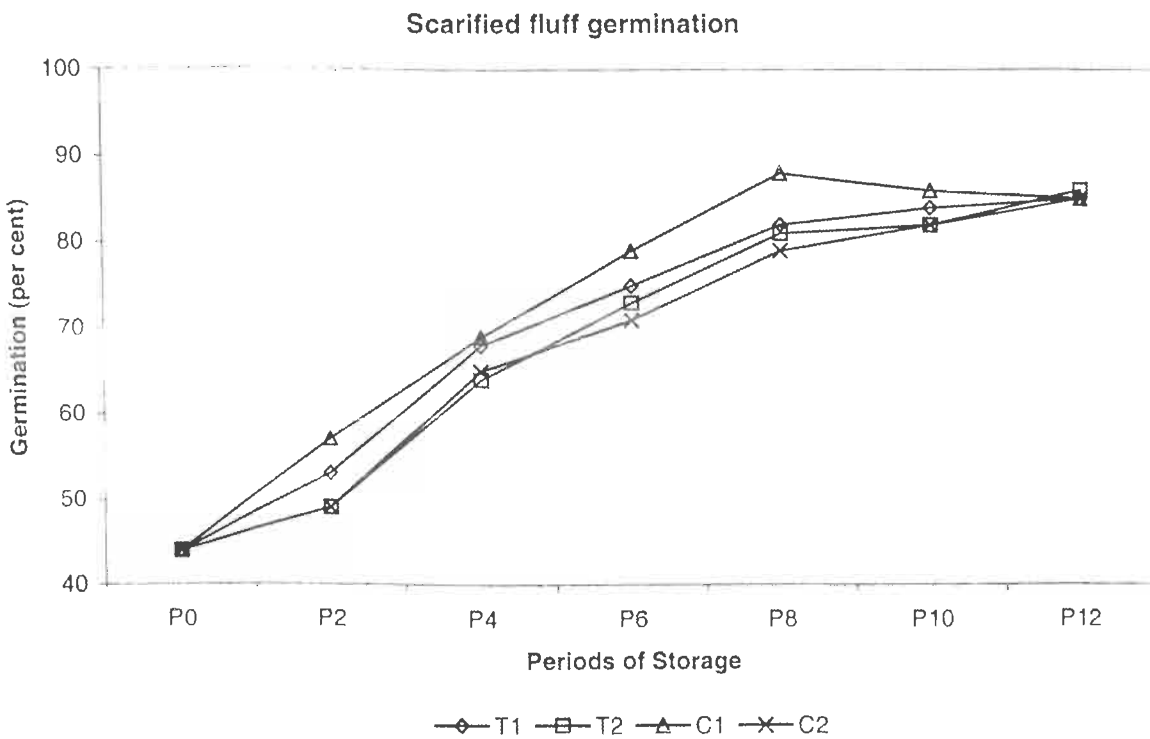
The moisture content of both unscarified and scarified fluffs packed in cloth bag showed gradual increase during monsoon months (August-December), which again reduced during summer months (March – April). Changes in seed moisture during storage were parallel to the changes in relative humidity. The relative humidity during monsoon months was high compared to summer months. The effect was more pronounced in cloth bags. Seeds are hygroscopic and cloth bags are moisture pervious enabling exchange of moisture between the seed and atmosphere. Sharma and Singh (1997) and Gupta (2000) also observed fluctuations in the moisture content of stored seeds according to the storage environment. The increase in moisture content of the scarified fluffs was more than in non scarified fluffs probably due to the digestion of the surrounding structures of the fluff by the acid treatment, which might have enabled more moisture absorbtion.

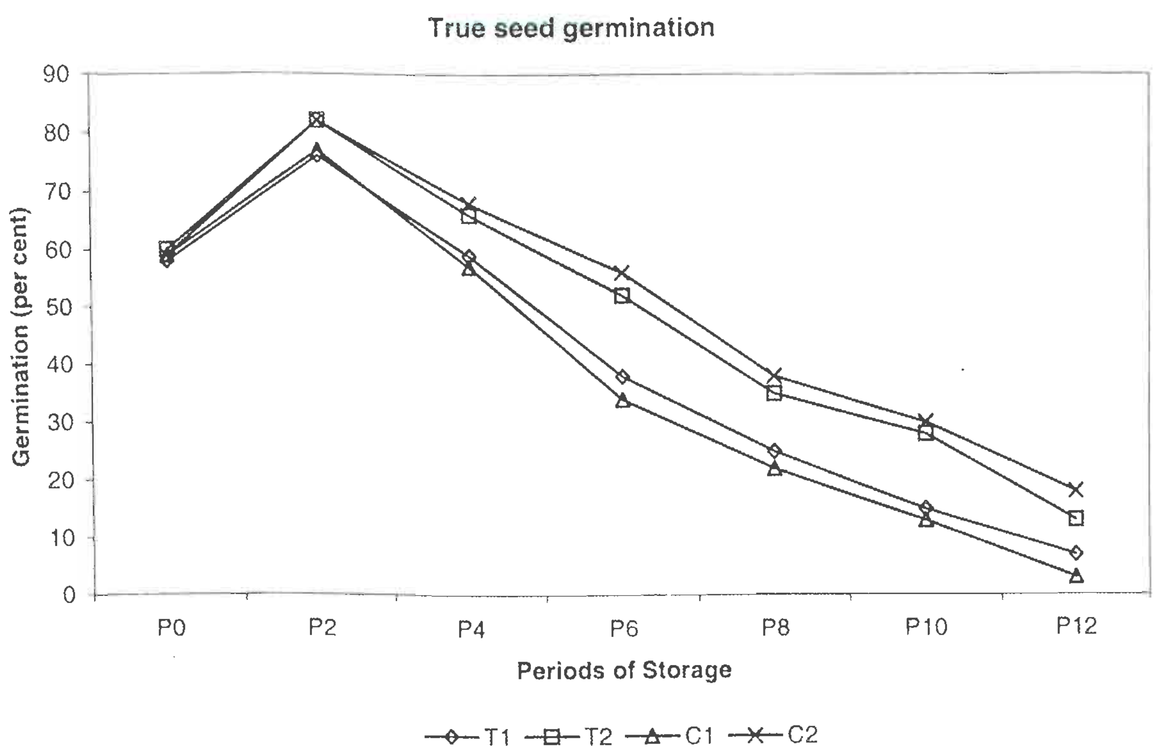
Fluffs packed in polybags also showed marginal increase in moisture content during storage but fluctuations with the atmosphere was not observed. This increase in seed moisture content in the polythene bag might have been due to the metabolic activities of the seed.

Germination and vigour of *C. glaucus* fluffs increased with advancing storage period. The increase was to the tune of 73 per cent and 48 per cent over the initial values in non scarified and acid scarified fluffs respectively. This might be due to the release and dissipation of dormancy during storage of seeds. Parihar *et al.* (1984a) and Jacqueline and Ramaswamy (1986) in *Cenchurs ciliaris*, Parihar (1986) in *C. setigerus*, Vijendradas (1990) in *C. glaucus*, Paramatma and Surendran (1990) in deenanath and guinea grass, Krishnarajan (1996) in guinea grass, Parihar and Rai (1985) in range grasses, Gonzalez *et al.*, (1993) in *Brachiaria decumbens*, Sanchez *et al.* 1999 in *B. humidicola* reported similar results.

Dormancy release and germination improvement in storage was greater for the fluffs stored in cloth bag than in polythene bag probably because enzymes were involved in dormancy release and whose activity would be more when the seed moisture was high (Fig. 9). In the present study, moisture uptake by fluffs was more in cloth bag than in polythene bag. Flores (1996) reported that *Brachiaria dictyoneura* seeds exhibited greater germination when stored in open bags than the closed bags.

Fig. 9. Effect of treatments, containers and periods of storage on scarified fluff and true seed germination





Seed germination in both non scarified and scarified fluffs increased and reached the maximum at twelve and eight months of storage respectively. After reaching the maximum germination level, it was maintained during subsequent storage without significant reduction, whereas seedling vigour as measured through root length, shoot length and vigour index showed marginal increase during the initial period of storage and started declining in due course proably because seedling vigour was more sensitive a parameter compared to germination to judge the physiological stamina of the seeds (Heydecker, 1972). Decrease in seed vigour during storage has been explained differently as due to reduced activity of enzymes (Ching, 1973); deterioration of cell membrane integrity (Koostra, 1973); impairment of DNA templates (Osborne *et al.* 1974) and increased incidense of chromosome abnormalities (Abdalla ad Roberts, 1968). In most of the storage studies, electrical conductivity of seed leachate showed steady increase with increased storage perid. Interestingly, in the present study, the electrical conductivity of stored fluffs decreased from the initial value of 0.117 to 0.096 and 0.106 to 0.074 dSm^{-1} in nonscarified and scarified fluffs respectively at four months after storage. This might be due to the loss of water soluble inhibitors during ageing. But after six months, steady increase in the electrical conductivity values was observed. The relationship of electrical conductivity of the seed leachate to the membrane integrity has been discussed in detail by Ching and Schoolcraft (1968) and Koostra and Harington (1969). The leachate exuded as measured by electrical conductivity had shown to be associated with the loss of vigour and viability (Hopper and Hinton, 1987; Hampton *et al.,* 1992; Dias and Marcos-filho, 1996). High electrical conductivity of seed leachate was accompanied by reduction in mobilization efficiency of DNA and RNA and ribonuclease enzyme activity (Srivsatava, 1975) and increased permeability arising out of oxidation of polar lipids of the membrane producing more pores (Koostra and Harington, 1969). In the present study also, the loss in vigour of the seeds as revealed by reduced seedling length reflected on the increased electrical conductivity of seed leachate eventhough germination showed minimum loss during storage.

The fluffs stored in 700 gauge polythene bags sustained minimum deterioration in seedling length, vigour and seed coat permeability when compared to seeds stored in cloth bag. The 700 gauge polythene bag formed an effective barrier to moisture, vapour and gas (Justice and Bass, 1978) and it would have also create oxygen tension and increase CO_2 accumulation inside the bag which would slowed down the respiration rate. Peel and Prondroff (1970) recommended sealed storage for *Panicum maximum* than open storage to maintain vigour and viability of seeds.

The halogen mixture treated fluffs (both non-scarified and scarified) showed improved vigour during storage than the untreated ones. The possible effect of treatment was consistently associated with reduced production of volatile aldehydes, which are persumably the product of lipid peroxidation (Wilson and McDonald, 1986). The carrier calcium carbonate even when used alone has been found to improve the storability of a number of seeds (Basu and Rudrapal, 1982; Bhattacharyya and Basu, 1990). The halogens act at the molecular level and stabilises the C=C double bond in the unsaturated fatty acids of the lipo protein moiety and making less susceptible to lipid peroxidation and free radicle reaction (Basu, 1994).

True seeds extracted from the fluffs were also studied for storage behaviour in the present investigation. Moisture content of true seeds followed similar trend as that of stored fluffs. It was the highest during monsoon months and lowest during April.

The germination of true seeds was increased by 25 per cent reaching 79 per cent during first two months of storage and then decreased to the minimum of ten per cent at the end of the storage period (Fig. 9). The loss was 87.3 per cent compared to the initial values. The tiny nature of true seeds associated with little protection and possibly because of the invisible injury inflicted during acid defluffing would have made them vulnerable for more deterioration as compared to fluffs protected by the glumes. Similar results with the loss of viabiilty of true seeds was noticed by several authors in grass seeds (Parihar *et al.* 1984a; Narayanasamy, 1996; White *et al.* 1999). The loss of viability was more (100 per cent) with untreated seeds stored in cloth bags than treated seeds in polythene bag containers. Seed treatment with halogen mixture reduced the loss in germination significantly due to the reasons discussed elsewhere. Compared to fluffs, true seeds lost viability faster probably the phenolic inhibitors associated with glumes might play a vital role in extending seed viability for longer period of time in the fluffs (Parihar *et al.*, 1984a; Parihar and Patil, 1986).

As compared to fluffs, where the germination improvement occured during later periods of storage (twelve and eight months in nonscarified and scarified fluffs respectively), true seeds exhibited germination improvement only upto 2 months period of storage probably because the intensity of dormancy in true seed was lower than that of fluffs.

Seedling length and vigour index of the stored seeds decreased gradually indicating the vigour loss of the true seeds which preceeds the viability loss. Unlike the storage behaviour of fluffs where the seedling vigour started declining only after six months of storage, true seeds showed steady decline in vigour from the beginning of storage.

Thus it was evident from the study that the fluffs of *Cenchrus glaucus* could be stored well in polybags after treatment with halogen mixture @3g kg^{-1} of seed for long term storage and before sowing, the seeds could be defluffed for easy sowing rather than storing the true seeds after extraction.

SUMMARY

CHAPTER VI

SUMMARY

Investigations were made in *Cenchrus glaucus* cv. CO 1, to determine (i) the influence of dates of sowing and cutting treatments on seed yield and quality (ii) seed development and maturation (iii) seed quality in different tillers of a plant (iv) the effect of temperature and media on seed germination (v) true seed extraction methods (vi) deck slope and air flow rate of specific gravity separator for seed quality upgradation (vii) dormancy breaking methods (viii) the effect of pelleting on plant establishment and (ix) fluff and true seed storage as influenced by seed treatment and container.

The experiment conducted to study the influence of dates of sowing and cutting treatments revealed that seed crop required longer duration to reach blooming during monsoon period.

The spike length and weight were reduced by cutting for fodder twice. Plants experiencing prolonged vegetative phase coinciding with monsoon period recorded more length and weight of the spike. The number of fluffs spike^{-1} and hundred fluff weight were significantly reduced by cutting treatments. The effect was more pronounced in crops raised during hot weather periods.

Seed yield was the highest in the seed crop sown on June 5th with no cut for fodder. The favourable weather conditions of rainfall, temperature and sunshine hours enabled higher seed set even when the crop was cut twice for fodder, which was evident in the crop sown on January 30th. High relative humidity with monsoon showers during seed development and maturation phase favoured disease incidence and reduced the seed yield considerably.

Models constructed based on regression analysis using weather parameters were effective in seed yield prediction.

Seed germination was not influenced by the dates of sowing but cutting treatments registered reduction in germination and vigour.

Seed development and maturation was traced for a period of 21 days after anthesis at three day intervals in proximal, middle and distal one third portions of the spike.

Length of the spike increased upto 9 DAA without any significant change thereafter.

The fresh weight of the spike and fluff was maximum at 15DAA which decreased gradually during subsequent stages of seed maturation phase.

Moisture content of both spike and fluff was maximum at 3DAA which decreased with maturity. This was associated with an increase in dry weight of the spike or fluff, which was maximum at 18DAA.

Number of filled seeds was maximum at 15DAA. The developing seeds (caryopses) started to germinate at 12DAA and reached the maximum at 18DAA.

Proximal portion of the spike registered the highest fresh and dry weight of spike. Total number of true seeds and filled seeds was also higher at the proximal end, eventhough the number of fluff spike^{-1} was higher at middle portion of the spike. Seeds in the proximal and middle portion of the spike were superior in germination and vigour to that of distal.

The results of tillerwise seed quality studies revealed that length and weight of the spike, number of seeds fluff^{-1} and 100 fluff weight were more in the first formed six tillers compared to last formed tillers.

Similar trend was noticed with seed germination which was maximum in the first formed tiller (first) which decreased gradually in the late formed tillers.

Studies on the effect of temperature and media revealed that seeds germinated faster at constant temperature of 30°C recording higher values for speed of germination. At the end of test period, seedling mortality occurred due to high temperature.

Seed germination and seedling quality characters *viz.*, root length, shoot length and vigour index were maximum at alternate temperature of 25-30°C.

Sand and roll towel medium performed well, producing vigorous seedlings with higher root and shoot length. Radicle emergence was delayed in sand medium.

True seeds extracted manually registered the highest seed recovery of 28 per cent with maximum germination and vigour. Mechanical defluffing and acid extraction for 20 min. caused to seed injury leading to low germination. Acid extraction of seeds for 16 min. recorded higher germination and vigour with minimum injury to seeds.

During specific gravity separation of fluffs, seed recovery was higher at 0 and 0.5 level of H and V scale adjustments respectively.

Air flow rate of 4 irrespective of the horizontal and vertical scale adjustments, registered increase in hundred fluff weight for the heaviest fraction of seeds.

Ill filled seeds were minimum at the H level of 1 irrespective of the vertical scale adjustment and at the air blow rate of 4.

Seed germination as well as seedling vigour measured through seedling length and vigour index revealed the beneficiary effect of specific gravity separation using the air flow rate of 4 with the V levels of 0 and 0.5, irrespective of the H scale adjustments.

Fluffs obtained in the higher level of three spouts were heavier seed fractions recording germination of more than 35 per cent which was well above the minimum seed certification standard of 30 per cent.

Studies on dormancy breaking methods revealed that the fluffs acid scarified for 4min., dried back and soaked in $CuSO_4$ (50 ppm) or ascorbic acid (25 ppm) solution for 16 h improved germination of fluffs. Seedling vigour was maximum with GA treated seeds.

True seeds soaked in $CuSO_4$ (50 ppm) or ascorbic acid (25 ppm) solution improved the germination to 80 per cent.

Seed pelleting studies revealed that seeds pelleted with $CuSO_4$ registered maximum germination and other nutrients used for pelleting did not significantly influence germination.

Seeds pelleted with DAP @60 g kg^{-1} of seeds in combination with $FeSO_4$ or $ZnSO_4$ @10g kg^{-1} of seeds registered the highest dry matter production and vigour index values, eventhough the field emergence was higher with seeds treated with $CuSO_4$.

Pelleting showed no deleterious effect on the storability of the seeds in terms of germination and vigour except the seeds treated with DAP.

Stored fluffs showed improved germination with advanced storage period due to release of dormancy.

In storage, the scarified fluffs packed in cloth bag absorbed more moisture which was parallel to the moisture fluctuations of the surrounding storage environment.

Non-scarified fluffs reached maximum germination at 12 months after storage, whereas scarified fluffs reached the maximum after 8 months of storage. Seedling vigour measured through root length, shoot length and vigour index showed significant increase during six months period of storage and started declining thereafter.

Germination of true seeds showed some improvement upto two months of storage which decreased gradually in the later periods.

Seeds stored as fluffs could maintain germination and vigour for longer period than true seeds. Halogen mixture treated fluffs and seeds stored in polythene bags preserved germination and vigour of seeds better than cloth bags.

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* Originals not seen.

ANNEXURES

ANNEXURE I

Morphological characters of *Cenchrus glaucus* cv. CO 1

Characters	Description
Plant habit	Perennial, tufted grass and decumbent
Plant type	Clumbs erect and gently bent from the root stocks
Leaves	Smooth leaf blade and hairy at the collar
Ligule	Narrow, ciliate and short
Shape of leaf	Linear, tip acuminate (basal leaves are short and upper leaves are long and narrow with pointed tip)
Leaf colour	Bluish green glaucus appearance
Node	Thick, prominent auxillary branches arise from each node looking like miniature bamboos
Stem	Solid, thin and soft, growing in a zig-zag manner
Inflorescence	Cylindrical raceme, light purple when young and turns straw (yellow) when mature
Spikelets	Surrounded by involucre of bristles
Rhizome	Rhizomatous roots

ANNEXURE – II

The mean maximum, minimum temperature, relative humidity, rainfall and sunshine hours during January 2000 to May 2001

Months	Maximum Temperature °C	Minimum Temperature °C	Relative Humidity at 7.022h (%)	Relative Humidity at 14.22h (%)	Rainfall (mm)	Rainy days	Sunshine hours
January 2000	30.7	19.5	89	46	2.0	-	7.1
February 2000	31.6	19.3	90	48	36.9	4	6.7
March 2000	34.5	20.9	86	32	-	-	9.4
April 2000	35.2	23.4	85	45	19.9	3	8.5
May 2000	35.3	23.4	81	41	13.9	3	8.6
June 2000	31.8	22.7	78	53	27.4	5	4.5
July 2000	31.5	22.7	78	50	15.7	2	6.0
August 2000	30.4	22.5	82	60	163.6	8	4.6
September 2000	31.6	22.2	89	59	210.4	9	6.5
October 2000	30.9	21.2	91	58	36.8	7	5.6
November 2000	29.9	20.8	90	53	75.3	4	5.9
December 2000	31.0	18.0	88	46	22.6	3	7.0
January 2001	30.3	19.7	87	44	-	-	6.2
February 2001	33.5	20.0	87	37	-	-	8.2
March 2001	35.3	22.1	80	35	-	-	8.7
April 2001	34.7	23.6	87	42	96.0	5	7.0
May	34.9	23.5	82	44	6.5	-	8.6